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THE ANNUAL REPORT FOR 1991

INTERNATIONAL ATOMIC ENERGY AGENCY

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FOR 1991

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INTERNATIONAL ATOMIC ENERGY AGENCY

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Note

1. All sums of money are expressed in United States dollars.

2. The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

3. The term "non-nuclear-weapon State" is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons.

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Introduction

The Agency has, in the past, frequently experienced difficult financial situations. In 1991, however, because one large contributor failed to pay, the financial situation deteriorated for the first time to a point where interference with a large number of activities could not be avoided. The cash shortfall was such that there was no alternative but to defer activities to a total amount of about $8 million, representing about 4% of the Regular Budget. The main items which were deferred to 1992 in the expectation that the arrears of 1991 contributions would be received during 1992 were as follows.

The activities (corresponding to $1.3 million) deferred in respect of programmes under Nuclear Energy and Safety were mainly related to meetings, research contracts and equipment. Under Research and Isotopes the largest portion of the activities ($1.1 million) deferred related to research contracts, while under Safeguards the total of $2.7 million represents almost exclusively equipment, as under General Services, where the sum of $500 000 is also related mainly to equipment. Of the Special Appropriation for the Acquisition of Major Equipment, the purchase of equipment equivalent to $1.3 million, related to data processing systems, was also deferred. The balance under Technical Assistance and Co-operation, Operational Facilities, Policy-making Organs and Executive Management and Administration represents a variety of items, including travel, interpretation for meetings, and consultants and other contractual services.

If the arrears of 1991 contributions are received during 1992 it will be possible to implement the above mentioned parts of the 1991 programme in accordance with the Agency's financial regulations. The authority to defer programmes has the merit of allowing the Agency to carry out programmes with some delay if the arrears of contributions are received in time for programme execution; however, the administrative effort necessary for the establishment, control and implementation of a deferred programme is considerable.

One of the important events in the Technical Co-operation area in 1991 was the decision of the Board of Governors to continue as a regular practice the two year programming process beyond the initial four year trial period (1989–1992). The two year cycle gives more time to appraise requests, and the Secretariat is able to discuss in more detail with Member States their obligations, the infrastructure available, the safety requirements of the projects, their connection with the overall national development plan of each country, and other multilateral or bilateral assistance under way.

A point of concern in 1991 was the decline in respect of pledges towards the Technical Assistance and Co-operation Fund (TACF) target. Notwithstanding the increase in the total value of resources ($49.1 million as against $44.6 million in 1990), the percentage of the target met through pledges declined to 78.4% from 85.3% in 1990.

In May 1991, a Senior Expert Symposium on Electricity and the Environment was convened in co-operation with the CEC, CMEA, ECE, IEA, IIASA, OECD/NEA, UNEP, WHO, WMO and the World Bank. The executive summary was presented to the secretariat of the United Nations Conference on Environment and Development.

The International Chernobyl Project was completed early in the year. The goals of the Project were to examine assessments of the radiological and health impact in areas of the USSR affected by the Chernobyl accident. The radiation health effects for people evacuated from the 30 km zone and emergency cleanup workers were not included in the study. The conclusions reached for the surveyed contaminated settlements were reported in an Overview and Technical Report.

INTRODUCTION

The publication of new recommendations by the ICRP (Publication 30) has led to the formation of a joint secretariat representing the Agency, FAO, ILO, OECD/NEA, PAHO and WHO with the purpose of preparing new Basic Safety Standards for protection against radiation and the safety of radiation sources. It also affected work on regulations for the transport of radioactive material.

After completion of a design review and safety review missions, the project on WWER-440/230 plants concluded the first phase of its objective with the issue of a document on the design deficiencies of this type of reactor and a ranking of their safety significance. The work provides a basis for operators and regulatory bodies to develop a programme for enhancing safety.

The conference on the Safety of Nuclear Power reviewed safety issues at the technical and policy making levels and formulated recommendations for future actions. The discussions centred on the following issues: fundamental principles for the safe use of nuclear power; ensuring and enhancing the safety of operating plants; treatment of nuclear power plants built to earlier safety standards; the next generation of nuclear power plants; and final disposal of radioactive wastes.

In the area of uranium resources, the eastern European Member States started to disclose previously unavailable data, which made the supply–demand picture of the world clearer.

The provision of technical assistance to eastern European countries in waste management and environmental restoration remains a critical challenge to the Agency. Some progress in this area was achieved in 1991 with the establishment of a regional project to provide advice on waste management activities for WWERs.

The Agency's role in promoting the use of nuclear science and technology to solve problems in Member States is carried out largely through activities under the research contract programme. Priorities in 1991 were driven by a range of factors, most importantly requests from Member States and the use of opportunities emerging from research trends. The recent United Nations Joint Inspection Unit evaluation report on the performance of UN system organizations mentions the research contract activities as perhaps the most important co-operative effort in the system.

Perhaps one of the most successful projects in this area, completed during 1991 in co-operation with FAO, was the campaign to eradicate screwworm flies from North Africa. This campaign, the major part of which began in August 1990, had the aim of eradicating the New World Screwworm from the Mediterranean and North African regions by the summer of 1992. Financial resources from donor countries amounting to some $80–90 million were estimated to be necessary to achieve this goal. However, the pest was totally eradicated one year ahead of schedule with less than $40 million of the donor contributions used — half of the original amount foreseen. The pest has been eliminated from a territory of some 25 000 km^2.

Under the Agency's crop production programmes, great progress was made in the use of radiation in combination with in vitro and double haploid technology for the genetic improvement of crops. The most spectacular results (of great importance for the breeding of hybrid rice) were obtained in China. In vitro culture and gamma irradiation resulted in highly desirable variation, as well as the selection of male sterile plants which are required to produce hybrid seeds.

With regard to environmental protection, studies on the fate of DDT revealed that it dissipates 4–30 times faster in tropical regions than in temperate regions. This is a very important discovery, since it shows that in tropical environments in developing countries DDT may be used as an economical, readily available and safe aid to agricultural production.

INTRODUCTION

As the only marine laboratory in the United Nations system, the Marine Environment Laboratory in Monaco (IAEA-MEL) played an integral role in the UN Interagency Plan of Action in the Gulf, which was initiated immediately following the cessation of the war in the region. Bringing both nuclear and non-nuclear techniques to bear on the question of marine pollution resulting from the hostilities, IAEA-MEL made the first quantitative, post-war assessment of oil and combustion product contamination in the waters of the Persian Gulf. The survey findings demonstrated that elevated levels of marine contamination were not widespread, but were restricted to the area between Kuwait and the oil contaminated coast of Saudi Arabia.

The year 1991 saw two important developments in the field of safeguards.

In Resolution 687, adopted by the Security Council of the United Nations in April, the Security Council requested the Agency to carry out immediate on-site inspection of Iraq's nuclear capabilities and to develop and carry out a plan for the destruction, removal or rendering harmless, as appropriate, of all nuclear weapons and nuclear-weapons-usable material or any subsystems or components or any research, development, support or manufacturing facilities related thereto. It also required the Agency to develop for the approval of the Security Council a plan for the future ongoing monitoring and verification of Iraq's compliance with its obligations under Resolution 687, including an inventory of all nuclear material in Iraq subject to the Agency's verification and inspections to confirm that the Agency's safeguards cover all relevant nuclear activities in Iraq.

During 1991 the Agency carried out eight inspections in Iraq and prepared a plan for the destruction, removal, or rendering harmless of the items referred to above, which was approved by the Security Council. The Agency also developed a plan for the future ongoing monitoring and verification of Iraq's compliance with Resolution 687 as well as the related Resolution 707. This plan was approved by Security Council Resolution 715.

On the basis of the on-site inspections, the Board of Governors was, for the first time, obliged to declare that a Member State was failing to comply with its safeguards obligations.

The second development related to the initiation of a debate on specific measures to strengthen safeguards. The General Conference adopted Resolution GC(XXXV)/RES/559 calling on the Board of Governors and the Director General to continue their efforts to maintain and strengthen the effectiveness and efficiency of the safeguards system in conformity with the Statute. Papers were prepared on the issues of special inspections, safeguards in nuclear-weapon States, safeguards considerations in the design of facilities, universal reporting of exports of nuclear material and significant quantities, and the Board of Governors began its consideration of some of these issues.

In November 1990, the Presidents of Argentina and Brazil signed the Argentine–Brazilian Declaration on Common Nuclear Policy. On the basis of this Declaration, the two States signed in July 1991 an agreement on the Exclusively Peaceful Utilization of Nuclear Energy. Under that agreement, they established a common system of accounting and control of nuclear materials (SCCC) and a Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), to administer and implement the SCCC. In addition, a safeguards agreement was negotiated between Argentina, Brazil, the ABACC and the Agency. This agreement is a comprehensive safeguards agreement of a special kind. It is compatible with the Treaty of Tlatelolco and meets the requirements of that Treaty concerning conclusion of a safeguards agreement with the Agency. It covers all nuclear materials in all nuclear activities carried out within the territories of Argentina and Brazil, under their jurisdiction or under their control anywhere. It also provides for the application of safeguards to exports of nuclear material subject to safeguards.

INTRODUCTION

In July 1991, South Africa became a party to the Treaty on the Non-Proliferation of Nuclear Weapons, and on 16 September 1991 the relevant safeguards agreement entered into force. At its XXXV regular session, in 1991, the General Conference in Resolution GC(XXXV)/RES/567, entitled "South Africa's nuclear capabilities", decided to request the Director General to ensure early implementation of the safeguards agreement. It also decided to request the Director General to verify the completeness of the inventory of South Africa's nuclear installations and material and tc report to the Board of Governors and to the General Conference at its thirty-sixth regular session.

Nuclear power

Nuclear power planning and implementation

Support for developing Member States

In connection with the programme to provide support for developing Member States, especially for nuclear power programme planning and development, including energy and nuclear power planning studies, project feasibility studies, infrastructure development planning, manpower planning and project management:

— Support continued to be provided to Malaysia in connection with the transfer of the microcomputer based Energy and Power Evaluation Program (ENPEP) package.
— Support was provided to Peru in connection with the review of energy and electricity demand studies and supply options using the ENPEP package.
— Assistance was provided to Romania in the conduct of energy demand forecasting and electricity expansion planning studies.
— A feasibility study for the implementation of small and medium power reactors in the long term power programme of Egypt was performed. The evaluation of the technical and economic aspects indicated that twin unit medium size power reactors would be competitive with coal fired plants of the same size from the levelized generation cost point of view under the reference assumptions adopted for the study.
— Work continued on preparing a technical report on the integrated package approach to nuclear power programme planning in developing countries. This report, which is intended to give guidelines for nuclear power planning advisory team missions to developing countries, is planned for publication in 1992.

Development and maintenance of computer models for energy, electricity and nuclear power planning

Agency methodologies (MAED, WASP, VALORAGUA, ENPEP) are widely used for energy, electricity and nuclear power planning. New developments include:

— Two new modules introduced into ENPEP to provide a more detailed treatment of electric system load curves and a more accurate simulation of the system operation.
— A microcomputer based version of VALORAGUA completed and offered to Member States.
— New releases of the various models made available to several Member States.

Several international organizations (e.g. the World Bank, the Asian Development Bank, the Inter-American Development Bank, CEC, OLADE, etc.) already use the planning models. Certain co-operative efforts with these organizations were initiated in 1991 for completion in 1992. These include:

— The application of ENPEP in CEC regional studies;
— The use of certain models within OLADE's development of a computer package for electricity expansion planning, adapted to the particular needs of the OLADE countries.

Use of computer models

	Number of releases of planning model or package			
	MAED	WASP	VALORAGUA	ENPEP
Member States	19	71	8	12
International organizations	4	6	—	2
Totals	23	77	8	14

EEDB

Development and maintenance of the Energy and Economic Data Bank (EEDB), as a source of reference data for both internal purposes and use by Member States, continued. Work on the development of a LAN based PC version (Micro-EEDB) providing faster and easier access was initiated. When completed in 1993, this new version could be made available to interested Member States.

Contracting and financing

Work continued on the preparation of a reference book on financing arrangements for nuclear power projects in developing countries.

A national seminar on the technical and economic evaluation of nuclear power plant bids was held in Czechoslovakia. An extrabudgetary project aimed at providing assistance in preparing for the implementation of the next nuclear power plant in Czechoslovakia was initiated.

Life management of nuclear power plants

The economics and decision making aspects of nuclear power plant life management were studied in co-operation with the OECD/NEA. It is planned to complete a report in 1992.

Assistance in nuclear power programme planning

Support continued to be provided to the National Atomic Energy Agency (BATAN), Indonesia, in training their personnel in the discharge of the owner's functions associated with carrying out the feasibility study for their first nuclear power plant.

Support was continued to Romania in the area of organizational structures and the division of responsibilities in the completion of the first unit at the Cernavoda nuclear power plant and gearing up for increasing domestic participation in the completion of the remaining four units.

Support continued to be provided to the Islamic Republic of Iran in the review of the Bushehr nuclear power plant and in manpower development.

An important move was made towards developing contacts and co-operation with maintenance management personnel in Bulgaria, Czechoslovakia and Hungary operating WWER-440 reactors with the objective of improving maintenance planning and performance and the introduction of an integrated maintenance indicator system. This project started with a technical meeting in Paks in May and was led by experts from the Barsebaeck plant, Sweden.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on integrated energy and electricity planning for nuclear power development with emphasis on the ENPEP package	USA	33	8 weeks
Regional course on nuclear power pre-project activities and manpower development	Republic of Korea	18	3 weeks

Publications

Series and No.	Title
IAEA Yearbook 1991	Nuclear power, nuclear fuel cycle and waste management: status and trends 1991
Reference Data Series No.1	Energy, electricity and nuclear power estimates for the period up to 2010: July 1991 edition
IAEA-TECDOC-607	Experience in energy and electricity supply and demand planning with emphasis on MAED and WASP among Member States of Europe, the Middle East and North Africa
IAEA-TECDOC-610	Financing of nuclear power projects in developing countries
IAEA-TECDOC-622	Experience in energy, electricity and nuclear power planning with emphasis on MAED and WASP among Member States of the Regional Co-operative Agreement (RCA) in Asia and the Pacific Region

Assessment and improvement of nuclear power plant performance

Good practices in nuclear power plant construction

An advisory group consisting of members with wide experience in the construction of nuclear power plants identified good practices which would result in shorter construction times, improved quality and safe and reliable performance during the operational phase. These ideas will be further reviewed and a technical document issued in 1992. Important considerations in designing new nuclear power plants for better constructibility, ease of maintenance and quick replacement of ageing equipment and components were also identified for inclusion in the document.

Power Reactor Information System (PRIS)

The main tool for assessing technical and economic performance in nuclear plant construction and operation is the Agency's Power Reactor Information System (PRIS). Since March 1989, PRIS has been offered free of charge for on-line access. Currently, 56 users in 25 Member States and 3 international organizations (WANO, the World Information Service on Energy (WISE) and OECD) have on-line access. The MicroPRIS package has been available, on the basis of the results of a research contract signed with the Nuclear Information Centre, Prague, since January 1991. MicroPRIS is a PC version of PRIS data, available on diskette in a form readily accessible by standard, commercially available PC packages. Currently, more than 100 subscribers in 43 Member States and 3 international organizations have the MicroPRIS package. The MicroPRIS User's Guide was published in 1991, being the first of the IAEA Computer Manual Series.

Information on PRIS

	1986	1987	1988	1989	1990	1991
Participating Member States	30	31	31	32	32	31
PRIS on-line:						
Organizations in Member States using direct access	—	—	—	32	36	39
Member States using direct access	—	—	—	20	23	25
Direct access users	—	—	—	39	51	56
International organizations using direct access	—	—	—	1	2	3[a]
MicroPRIS						
MicroPRIS subscribers	—	—	—	—	—	107
International organizations using MicroPRIS	—	—	—	—	—	3[a]
Member States using MicroPRIS	—	—	—	—	—	43
Power reactors in operation included in the system	330	389	408	426	423	420[b]
Reactor years of experience reported (cumulative values)	3411.3	3792.3	4194.3	5200	5622.9	6275[b]
Data sets supplied on request	—	3	23	25	56	47

[a] OECD, WANO, WISE.

[b] Estimates.

Nuclear power plant availability

Co-operation with the World Energy Council (WEC) and the International Union of Producers and Distributors of Electrical Energy (UNIPEDE) continued in studies related to the availability of electrical power and the harmonization of international definitions. The Agency is the main contributor to data on nuclear power plants. In 1990, the world average energy availability of nuclear plants was about 70% (69.7% in 1989). PHWR plants presented the highest cumulative energy availability, about 74%, while PWRs corresponded to 69.6% and BWRs to 64.5%.

Seminar on efficient outage planning and management practices in nuclear power plants

The importance of efficient management of the varied activities carried out during planned plant outages and its impact on the plant operating performance was the subject of a seminar held in April in Vienna. The seminar was attended by participants representing nuclear utilities and operations support organizations in 22 Member States and 2 international organizations. The objectives of the seminar were:

- To encourage a better awareness in utilities of good management practices that support effective execution of outage activities.
- To provide a forum where participants from utilities with successful outage management programmes can share their experience and exchange information.
- To foster international co-operation in the development of good outage management practices.

The utilities participating in the seminar represented a wide cross-section of reactor types, sizes and organizational structures. Outage management practices were reported to be plant/utility specific though there were certain common elements. Outage performance indicators were discussed and their effectiveness in trending outage performance stressed.

IWG-NPPLM

The activities of the International Working Group on Nuclear Power Plant Life Management (IWG-NPPLM) contributed considerably to: formulating a systematic approach and methodology for the management of nuclear power plant ageing processes; establishing a methodology to rank plant components according to their impact on plant lifetime; developing a database on properties of irradiated materials; defining the specifications for a suitable database for merging operating experience and classifying the consequences of operating events on the lifetime of plant components; and contributing to a better understanding of the ageing phenomena and their mechanisms.

IWG-NPPCI

At a meeting of the International Working Group on Nuclear Power Plant Control and Instrumentation (IWG-NPPCI), delegates summarized operating experience with instrumentation and control systems, presented a general overview of recent developments and made recommendations for further activities in the area during the period 1992–1994.

A symposium on nuclear reactor surveillance and diagnostics (SMORN-VI), organized jointly by the OECD/NEA and the IWG-NPPCI, was held in Gatlinburg, USA. The meeting covered traditional noise analysis as well as the development and application of surveillance and diagnostic techniques useful for ensuring the operational readiness of components and systems important to plant safety and economical operation. The symposium demonstrated that monitoring of mechanical structures in nuclear power plants on the basis of vibration, neutron noise and dynamic pressure signals has reached a well developed state

IWG-NPPCI (cont.)

with respect to the understanding of the physical phenomena involved and of signal analysis methods and monitoring systems. Vibration monitoring of reactor internals and primary circuit components has become — next to loose parts and acoustic monitoring — the most widely applied method for early fault/degradation monitoring in PWRs.

Revision of the quality assurance NUSS Code and Safety Guides

Work was continued on the revision of the NUSS quality assurance publications to reflect developments in quality management techniques that now place greater emphasis on 'right first time' rather than on finding and correcting mistakes. The opportunity is also being taken to align the publications more closely with other quality standards, such as those from ISO. A revised framework for the publications was prepared to enable and expedite a consistent review of the whole NUSS quality assurance system.

Safety Guide on quality assurance for nuclear power plant siting

Work was also continued on the preparation of a draft text of a new NUSS Safety Guide to cover acceptable methods of implementing quality assurance requirements during the site selection stage. The draft document was incorporated in the revised framework developed for the NUSS quality assurance system.

Effective quality management practices

Work was initiated on a technical document on guidance for improving quality management and quality assurance programmes in nuclear installations. The document is aimed at senior (corporate) nuclear managers and site superintendents and managers reporting directly to them. The objective is to identify significant management issues which affect plant performance and to provide pragmatic advice on effective practices which have proved useful in addressing these issues.

Quality assurance integrated training packages

Work was completed on a technical report which provides guidance on the implementation of quality assurance training programmes for all personnel performing activities affecting the quality of a nuclear power plant or other nuclear installations. The document was developed on the basis of the experience and material collected through more than fifty interregional, regional and national training courses, seminars and workshops on quality assurance.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on quality assurance in nuclear power plant operation	Spain	18	5 weeks
Workshop on statistical quality control methods	Republic of Korea	26	2 weeks
Workshop on quality assurance for activities related to siting and design against external hazards	Bulgaria	76	2 weeks
Workshop on quality assurance in the design of nuclear power plants	China	30	2 weeks
Workshop on quality management during the construction and operation of nuclear power plants	Argentina	20	1 week
Interregional course on instrumentation and control of nuclear power	Germany	28	5 weeks

Publications

Series and No.	Title
Technical Reports Series No. 328	Grading of quality assurance requirements: a manual
Reference Data Series No. 2	Nuclear power reactors in the world: 1991 edition
Annual publication	Operating experience with nuclear power stations in Member States in 1990
IAEA-TECDOC-609	Assessing the effectiveness of quality management for nuclear power plant operations
IAEA-TECDOC-612	Analysis of replies to an IAEA questionnaire on procedures for accreditation of training programmes and for authorization and licensing of nuclear power plant operations personnel
IAEA-TECDOC-621	Good practices for outage management in nuclear power plants
Computer Manual Series No. 1	MicroPRIS user's guide: a version of the Power Reactor Information System (PRIS) for PC users

Improvement of reactor technologies

IWGATWR

At its 4th meeting in Winfrith, United Kingdom, the International Working Group on Advanced Technologies for Water Cooled Reactors (IWGATWR) reviewed the status and progress on advanced technology development and trends in water reactor designs along with related national programmes. A particular highlight in the field of new design concepts was the further progress in the common project for a 1450–1500 MW(e) PWR licensable in France and Germany. A detailed description of design features and safety goals for next generation reactors was presented at the meeting. The Group also endorsed the Agency's proposals to prepare a document on the desired characteristics for advanced reactor systems and to prepare status reports on: methods and ways to reduce the costs of nuclear power plants; advanced containment technologies; and the design and operational margins for advanced water cooled reactors.

Development of advanced water cooled reactors

A Technical Committee meeting in Rome on the development and design aspects of advanced water cooled reactors provided a forum for specialists to review progress and to identify advanced features for safety and operational improvement. The main conclusions of this meeting were:

- There is a need for clearly stated, technically sound design requirements for ALWRs.
- There is also a need for achieving public acceptance as a precondition for building new plants. These plants should not require relocation of people under credible accident conditions.
- New technologies under discussion are promising but should be adopted very cautiously, after exhaustive testing of both components and systems; the use of passive systems with special emphasis on natural coolant circulation has merits but only to the degree that such systems result in improvements.
- Improved containments are the easiest and possibly the best way to meet the goal of increased safety.

Materials for advanced water cooled reactors

A Technical Committee meeting in Pilsen, Czechoslovakia, carried out a review of the historical development of various materials used for the construction of primary circuit components (reactor, steam generator, pipings, valves and pressurizer). The results of an analysis showed that technology has reached a level which provides a reliable basis for the safety and structural integrity of components for advanced water cooled reactors. Data on components, operational parameters, material parameters, chemical composition, mechanical properties, structural features and safety requirements were analysed at the meeting. A better understanding of long term degradation mechanisms is needed. A comparison of material codes, together with material testing methods, is necessary for key components of the reactor primary circuit.

Thermophysical properties database

The first research co-ordination meeting for the CRP on the establishment of a thermophysical properties database for light and heavy water reactor materials was held in Stuttgart, Germany. The purpose of the meeting was to review the results obtained and to formulate additions to the programme of the CRP. The meeting was attended by participants from China, Czechoslovakia, Germany, India, the USSR and Yugoslavia. The specifications for a database for thermophysical properties of light and heavy water reactor materials were identified.

IWGFR

At its 24th annual meeting, the International Working Group on Fast Reactors (IWGFR) reviewed the status and current trends in national and international LMFR development programmes.

- France has initiated a programme on innovative studies aimed at proposing new concepts for FBRs. These studies are based on an analysis of the options selected for existing reactors and projects, and also of the advanced concepts envisaged by other countries for future projects.
- In Japan, construction work on the prototype reactor Monju has been completed on schedule, and pre-operational tests on sodium were carried out. Design and R&D studies are in progress to develop a demonstration fast breeder reactor.
- In the USSR four fast reactors were in operation and considerable operating experience on the whole complex of equipment and sodium systems has been obtained. This experience was being closely analysed and its results used for designing advanced plants — more reliable and safer than existing ones. Conceptual design was under way on the large size BN-1600 reactor.
- Emphasis in the Integral Fast Reactor Program in the USA was on the comprehensive development of technology, to be followed by a period of demonstration which would verify economic feasibility. Development was focused on parametric investigation of the performance of the U–Pu–Zr ternary alloy metallic fuel.
- In China, the conceptual design of the First Fast Reactor (FFR) has recently been basically completed. An application for the construction of the FFR has been submitted to the Government.
- The design of a 1500 MW(e) unit by the European Fast Reactor Utilities Group (EFRUG) continued. A comprehensive package of options emerged as part of the current so-called consistent design, which includes innovative features. These new features should offer significant cost reduction and/or safety advantage and be capable of development on a reasonable and affordable time-scale. An essential requirement is that the design must be able to be licensed in any of the partner countries.

Passive and active safety of LMFRs

In the framework of the technical information exchange activities of the IWGFR, a specialists meeting on passive and active safety features of liquid metal fast reactors was held at the Oarai Engineering Center, Japan. It was noted that there had been dramatic improvement in the general understanding of the parameters which must be addressed in the design and analysis of fast reactors to ensure their safe response to accident situations. Current fast reactor designs offer very large margins of safety and by virtue of redundant and diverse safety systems the potential for an energetic core disruptive accident or for fast reactor core meltdown has been essentially eliminated; the availability of engineered core safety features — either control systems or flow coastdown — is sufficient to prevent major core damage.

LMFR plant parameters

Seven Member States have major fast breeder reactor development programmes — with eleven LMFRs in operation. Three European countries have established a project to design the European Fast Reactor. Four more Member States have R&D activities in the field of fast reactors or programmes related to the development of LMFBR components.

LMFR plant parameters (cont.)

To promote international co-operation and technical information exchange in this field, the Agency prepared an updated report with information on the status of fast breeder reactor development worldwide. It contains updated parameters of 27 experimental, prototype and commercial LMFBRs. Most of the reactors are presently in operation, under construction or in an advanced planning stage. Parameters for the Clinch River Breeder Reactor (USA), PEC (Italy), Rapsodie (France), DFR (UK) and EFFBR (USA) are included because of their important role in the development of LMFBR technology. Two new reactors appeared in the list: the European Fast Reactor (EFR) and PRISM (USA).

Reactor physics

The CRP on safe core management with burnable absorbers in WWERs, aimed at improving knowledge on burnable absorbers for use in WWERs, was continued. During a Research Co-ordination meeting held in Řež, Czechoslovakia, the results of critical experiments with gadolinium absorber rods, benchmark calculations on square and hexagonal lattices and intercomparisons of the critical experiments with the calculations, were reviewed.

During a Technical Committee meeting held in Řež, worldwide studies on reactor physics aspects of core design parameters of water cooled reactors were discussed. Participants analysed benchmarks for various lattices containing gadolinium as a burnable absorber and compared calculations with experimental or plant operational data. Methods for reactor core parameter calculations and in-core fuel management were also discussed.

Progress was made in the CRPs on in-core fuel management benchmarks for LWRs and for PHWRs. In the former, interest was expressed by originally non-participating institutes to perform the benchmark calculations for the WWER reactors and to compare these with operational results. For the latter, new benchmark tasks were defined — for secondary shutdown systems, simulation of loss of regulation accident analysis and the influence of isotopic composition on the void effect.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	In-core fuel management code package validation for LWRs	1992	16
1988	Safe core management with burnable absorbers in WWERs	1992	9
1989	Acoustic signal processing for the detection of boiling or sodium–water reactions in LMFBRs	1992	7
1989	Benchmark for in-core fuel management programs for PHWRs	1993	7
1990	Establishment of a thermophysical properties database for light and heavy water reactor materials	1994	7

CRPs established in the current year

Subject	No. of years	Participating institutions
Intercomparison of LMFBR seismic analysis codes	3	7

Publications

Series and No.	Title
IWGATWR/4-1	Advanced technologies for water cooled reactors 1990: part 1
IWGATWR/4-2	Advanced technologies for water cooled reactors 1990: part 2 (proceedings of the third meeting)
IWGATWR/5	Methods and technologies for cost reduction in the design of water cooled reactor power plants
IWGFR/78	Steam generator failure and failure propagation experience
IWGFR/79	Acoustic/ultrasonic detection of sodium water leaks in steam generators
IWGFR/80	LMFBR plant parameters 1991
IWGFR/81	Review report on the IWGFR activities for the period since the 23rd annual meeting of the IWGFR
IWGFR/82	Summary report of the 24th annual meeting of the International Working Group on Fast Reactors
IWGFR/83	Status of national programmes on fast breeder reactors
IAEA-TECDOC-626	Safety related terms for advanced nuclear plants

Development of advanced reactor systems

Advanced reactor system development

A Technical Committee meeting and workshop reviewed the role of the Agency in the development of advanced reactor systems, with special attention to the needs of developing countries. The objectives of advanced reactor system development have been to enhance safety and reliability, to improve economics, to increase the efficiency of the fuel cycle and to gain better public acceptability. To achieve these objectives, it was recommended that the role of the Agency should be to:

- Assist Member States in the development, evaluation and implementation of advanced reactor systems through effective international co-operation.
- Identify the necessary R&D efforts for innovative concepts and promote sharing of these efforts among Member States with special emphasis on: severe accidents; containment technologies; fuel utilization and waste management; and economics.
- Improve public acceptance by preparing authoritative and objective information about advanced reactors.

IWGGCR

At the 10th meeting of the International Working Group on Gas Cooled Reactors (IWGGCR) it was noted that an important milestone in GCR development had been reached in March with the start of construction of the High Temperature Test Reactor (HTTR) at the Oarai Research Establishment of the Japanese Atomic Energy Research Institute (JAERI). The HTTR will produce a core outlet temperature of 950°C and will be the first nuclear reactor in the world to be connected to a high temperature process heat utilization system. In the UK, where about 20% of the total electricity is generated by gas cooled reactors, the Oldbury power station set a new world record for continuous operation of a commercial reactor. Design and technology development activities continued in the USA on the Modular HTGR and in the USSR on the VGM and the VG-400 plants. In Germany, while industry has greatly reduced its efforts to commercialize the HTR, research especially geared towards a modular HTR is continuing.

Members of the IWGGCR reviewed the international project under way at the Proteus critical experiment facility of the Paul Scherrer Institute in Switzerland. They also advised that the Agency establish new co-operative activities in the fields of decay heat removal and fuel and fission behaviour during accidents.

Status of graphite development

As part of technical information exchange and international co-operation, a specialists meeting was held at the Tokai Research Establishment on the status of graphite development for gas cooled reactors. The status of the work and the results achieved so far, including graphite R&D activities conducted to support HTTR licensing, operating experience from graphite moderated reactors in the France, UK and the USA, and development work in Germany, the USSR and the USA were reported. Recommendations were also made for future priorities in R&D.

International research project

The CRP on the validation of safety related physics calculations for low enriched gas cooled reactors continued. Research workers from six Member States participated in the international team assembled at the Proteus experiment facility in Switzerland in planning a new series of critical experiments aimed at filling gaps in validation data for analytical tools used in the participating

International research project (cont.)

countries for the design of current gas cooled reactor concepts. Also, detailed validation data from the Japanese VHTRC critical experiment facility was provided to participating Member States.

Seawater desalination

The 34th session of the General Conference adopted Resolution GC(XXXIV)/RES/540 requesting the Agency to assess — in detail within its competence and with the assistance of international and other organizations concerned and also making use of cost free experts whenever possible — the costs of potable water production with various sizes of nuclear desalination plant at selected promising sites and to compare these with the costs of desalination by other means.

A number of North African countries (Algeria, Egypt, the Libyan Arab Jamahiriya, Morocco and Tunisia) submitted a request to the Agency for assistance in carrying out a feasibility study on nuclear desalination for some selected sites in their region. This request has been considered as part of the activities to be performed in compliance with the above mentioned resolution. Consequently it was decided to proceed simultaneously with general assessment studies of nuclear desalination and the feasibility study. The general assessment studies would provide an essential input for the feasibility study, which in turn would serve as a practical case study.

The Agency established contacts with other international organizations working on water resource assessment activities and convened meetings with desalination and nuclear experts and representatives from the North African countries involved to define a suitable programme.

To obtain economic and technical data on desalination by means of nuclear energy and fossil energy, questionnaires were sent to relevant Member States and the data were discussed during an Advisory Group meeting in Vienna.

Regional meetings were convened in the North African countries to review the progress achieved. A report on the studies undertaken was presented at the General Conference.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Validation of physics calculations for low enriched HTGRs	1995	6

Publications

Series and No.	Title
IWGGCR/21	Status of national gas cooled reactor programmes
IWGGCR/24	Uncertainties in physics calculations for gas cooled reactor cores
IWGGCR/25	Behaviour of gas cooled reactor fuel under accident conditions
IWGGCR/26	Ninth meeting of the international working group on gas cooled reactors
IAEA-TECDOC-615	Nuclear applications for steam and hot water supply

Nuclear fusion

Fusion research and engineering

In co-operation with the International Thermonuclear Experimental Reactor (ITER) project, a CRP on lifetime behaviour of the first wall of fusion machines continued. On the basis of common input data, thermal and mechanical analyses of a benchmark first wall component were performed by participants from Japan, the USSR, the CEC and the Next European Torus (NET) team to compare lifetime predictions. Results will also be compared with the behaviour of a first wall component which is undergoing thermal cycling testing at the Ispra research establishment. A next step is being planned to select a benchmark exercise and companion experiment to investigate the influence of defects (fabrication defects or defects introduced by plasma disruption) on first wall lifetime under thermal cycling conditions.

International fusion training and research centre in China

The Agency has received proposals from China to co-operate in establishing an international fusion training and research centre. The proposed sites are the Institute of Plasma Physics, Academia Sinica, in Hefei, and the Southwestern Institute of Physics, in Chengdu/Leshan. Agency staff visited these two institutes in September/October to evaluate the current and planned scientific and technological programmes of the institutes, the scientific background and qualifications of the staff, the status of current international collaborations, and the available financial resources.

Software development

A new CRP on the development of software for numerical simulation and data processing in fusion energy research has been approved. The purpose is to develop numerical codes and programmes that are needed for accurate performance predictions for large fusion devices which are now entering the engineering design phase. Some of this software will be useful to, and affordable by, small plasma physics laboratories in developing countries.

***Nuclear Fusion* journal**

Twelve regular issues of *Nuclear Fusion* were published, comprising 128 full articles, 50 letters, and 20 conference reports, among which were the summary papers of the 13th Conference on Plasma Physics and Controlled Nuclear Fusion Research (Washington, 1990). Of particular importance was the ITER conceptual design study, the major results of which were published as a special topic in issue No. 4.

The sixth edition of the special supplement to *Nuclear Fusion*, the World Survey of Activities in Controlled Fusion Research, was issued.

The first volume of the new journal *Atomic and Plasma-Material Interaction Data for Fusion* was published as a supplement to *Nuclear Fusion*. Most of the articles for the second volume were prepared.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Lifetime behaviour of the first wall of fusion machines	1994	5

Publications

Series and No.	Title
Proceedings Series	Plasma physics and controlled nuclear fusion research 1990
Annual publication	World survey of activities in controlled fusion research: 1991 edition
ITER Documentation Series No. 15	Twin-loop for vertical control of highly elongated plasma
ITER Documentation Series No. 16	ITER conceptual design activities: final report
ITER Documentation Series No. 17	ITER Council proceedings: June 1990 - December 1990
ITER Documentation Series No. 18	ITER conceptual design report
ITER Documentation Series No. 19	Physics and technology R&D for ITER conceptual design
ITER Documentation Series No. 20	Research and development needs for ITER engineering design
ITER Documentation Series No. 21	ITER physics
ITER Documentation Series No. 22	ITER parametric analysis and operational performance
ITER Documentation Series No. 23	ITER operation and research programme
ITER Documentation Series No. 24	ITER test programme
ITER Documentation Series No. 25	ITER tokamak device
ITER Documentation Series No. 26	ITER magnets
ITER Documentation Series No. 27	ITER poloidal field system
ITER Documentation Series No. 28	ITER containment structure
ITER Documentation Series No. 29	ITER blanket, shield and materials database
ITER Documentation Series No. 30	ITER plasma facing components
ITER Documentation Series No. 31	ITER fuel cycle
ITER Documentation Series No. 32	ITER current drive and heating system
ITER Documentation Series No. 33	ITER diagnostics
ITER Documentation Series No. 34	ITER assembly and maintenance
ITER Documentation Series No. 35	ITER plant systems
ITER Documentation Series No. 36	ITER safety
Newsletter	ITER newsletter, Vol. 3, No. 12 and Vol. 14, Nos 1-4
IAEA-TECDOC-594	Superconducting materials and magnets
IAEA-TECDOC-604	Research using small tokamaks
Newsletter	Plasma physics network newsletter, Nos 3 and 4

Nuclear fuel cycle

Environment and the nuclear fuel cycle

An Advisory Group meeting was held in Vienna on the environmental impact and related public concerns regarding the nuclear fuel cycle. Eleven participants from 8 countries participated in this final meeting to complete a report which is believed to be the first document published on this subject.

Planning of nuclear fuel cycle facilities in developing countries

An Advisory Group meeting was held in Vienna to prepare a document for publication on the planning of nuclear fuel cycle facilities in developing countries. The results obtained from an international training course on this subject held in Bariloche, Argentina, in 1990, will be used as background material. One of the outcomes of the study was that developing countries should be encouraged to procure the necessary technologies and services rather than develop their own domestic technologies. The draft of the report is now at a final stage.

Nuclear Fuel Cycle Information System (NFCIS)

Information on nuclear fuel cycle facilities contained in the personal computer (PC) version of the NFCIS database was verified and updated. Summaries, listings of individual facilities and maps showing the geographical distribution of facilities were also produced. Information relating to particular countries was sent for verification to 50 Member States. With the information received a new update of the NFCIS database will be produced.

Raw materials for reactor fuels

Supply-demand analysis

Uranium production in WOCA in 1991 is expected to decline further by about 2000 t, to 28 000 t U in response to unfavourable market conditions. Nine countries produce nearly 95% of the total, and eight countries contribute the remaining 5%. Reactor related uranium requirements in 1991 were about 44 500 t U. The resulting underproduction came to approximately 16 500 t, which was covered by material held in stocks and inventories in WOCA as well as by imports from China and the USSR.

Low cost supply based upon the expected production from WOCA producer countries through the year 2010 is projected to be in the range of 15 000 t U, while uranium requirements are expected to grow to 57 000 t U. This estimated production gap, which will reach over 40 000 t U in 2010, and cumulatively about 350 000 t, may be filled partly by WOCA stocks and imports, but will require more production centres in addition to those which are currently existing and committed.

New developments in uranium exploration, resources and demand

A consultants meeting on the long term analysis of uranium supply and demand was held in Vienna. Three uranium supply-demand projections, through 2005, 2020 and 2035, were analysed using different approaches and resource and supply data. The results of the analyses covering the different time-frames coincided well for the overlapping time periods with regard to the drawdown of WOCA stocks and the need for additional production centres, as well as the sufficiency of uranium resources. A comprehensive report on these projections and their analyses was drafted and presented at the OECD/NEA-IAEA Technical Committee meeting on new developments in uranium exploration, resources, production and demand, held in Vienna. The meeting drew 56 specialists from 26 countries. Twenty nine papers on the subject were presented, among them reports on two discoveries of world class uranium deposits in Saskatchewan, Canada, as well as the first presentations in the West on uranium resources in the USSR.

'Red Book'

A new edition of the 'Red Book', a joint report of the OECD/NEA and the Agency, is in preparation. It will contain more complete statistics on uranium resources, supply and demand, as well as supply-demand projections through the year 2010. A growing number of Member States which previously did not provide data for this report are participating in this effort. Publication is foreseen in early to mid-1992.

World atlas of uranium deposits

Preparation of a world map of uranium deposits continued, with a second consultants meeting which reviewed information submitted by a number of Member States. Among the most important was the information on 88 deposits provided by the consultant from the USSR. As a result, the database for the atlas now contains information on about 430 uranium deposits, making the goal of producing a complete world atlas of uranium deposits closer to realization.

Economic feasibility study for uranium projects

A report is being prepared within the framework of a consultants meeting on a progressive approach to a uranium feasibility study which is expected to provide workers in this field with guidance on how to assess uranium projects on a systematic, step by step basis, from the very early stages of the programme.

Management of earth sciences data on PCs

A draft document on the management of earth sciences data on a personal computer was completed. Although this document was prepared to provide guidance on organizing and managing the enormous amount of data collected during past uranium exploration activities, it can easily be used for other databases as well in general mineral exploration and earth sciences programmes, which are new and growing areas of activity in many developing countries. The document is expected to be issued in 1992.

Computerized database of radioactive minerals

A computerized database of 528 radioactive minerals, containing relevant chemical and physical parameters, was created. This stand-alone and easy to use database system was prepared to supplement a report on uranium mineralogy, which is in preparation and is expected to be completed in 1992.

GIS

The Geographical Information System (GIS) is a computerized graphic mapping program which facilitates the integration and management of different types (layers) of information. Preparation of a guidebook on spatial data integration for mineral exploration, resource assessment and environmental studies using GIS was initiated in 1991. Although the document is aimed primarily at those involved in mineral exploration and at resource specialists, it is considered to be useful for environmental specialists, waste management specialists, emergency response teams and others who are concerned with spatial data presentation.

Monograph on uranium extraction technology

A consultants meeting finalized a monograph on uranium extraction technology, which was submitted for publication. The document (over 300 pages) represents the most comprehensive report on the subject published over the past ten years and is expected to become an important reference work in the field of metallurgy, in particular for uranium. It will be issued in the Agency's Technical Reports Series.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on exploration drilling and ore reserve estimation in uranium exploration	India	15	4 weeks
Regional workshop on technical co-operation project counterparts in the field of uranium raw materials in the Asia and Pacific region	China	8	2 weeks

Publications

Series and No.	Title
Technical Reports Series No. 323	Airborne gamma ray spectrometer surveying
IAEA-TECDOC-583	Uranium exploration planning and practice
IAEA-TECDOC-595	Guidebook on the development of projects for uranium mining and ore processing
IAEA-TECDOC-597	Assessment of uranium resources and supply

Reactor fuel technology and performance

IWGFPT

The International Working Group on Water Reactor Fuel Performance and Technology (IWGFPT) met in Vienna with the participation of 26 experts representing 19 Member States. Activities in the areas of fuel performance and technology were reviewed and guidance established. The interest of Member States continued to be on fuel reliability at extended burnup. Four reports relating to IWGFPT activities were published.

Poolside inspection repair

A Technical Committee meeting on poolside inspection repair and reconstitution of water reactor fuel elements was held in Lyon, France, with the participation of 36 experts from 12 Member States. The meeting provided a useful forum for the exchange of views and represented a continuation of earlier Agency meetings (1981, 1984, 1987). The techniques reviewed, developed mainly by fuel suppliers, are now used routinely and with success. Computerization and automation of poolside examination, repair and reconstitution have been the main factors in the progress towards better reliability, dose/waste reduction and better economics. However, there is still room for improvement in the areas of examination repair and reconstitution and refuelling strategies, in particular of failed fuel.

Recycling of U and Pu and MOX fuel technology

An Advisory Group meeting on the economics of the recycling of U and Pu and the status of MOX fuel technology was held in Pierrelatte, France, with the participation of 27 experts from 8 Member States. This meeting confirmed the progress achieved by industrial undertakings in the field and the adequacy of both existing experience and ongoing programmes for the management of reprocessed U and Pu which will become available from the operation of reprocessing plants. Although MOX fuel is known to perform well in the reactor, and data are accumulating to confirm this, much higher burnup is required to obtain better economy. The meeting also noted diverging opinions, reflecting the options chosen by each of the Member States represented.

Impact of extended burnup on the fuel cycle

An Advisory Group meeting on the impact of extended burnup on the nuclear fuel cycle was held in Vienna with the participation of 20 experts from 13 Member States. There was a consensus among the participants that economic and environmental benefits are the driving forces behind the achievement of higher burnup. The purpose of the meeting was to summarize the main technical issues. In considering these issues, the Advisory Group confined its deliberations to batch average burnup levels, which were seen as feasible goals achievable within the next 15 years. For water reactors this is seen as 55–60 GW·d/t U for PWRs and WWER-1000s and 45–50 GW·d/t U for BWRs and WWER-440s. For heavy water reactors this would be 12–20 GW·d/t U. The impact of extended burnup was considered under three main headings: extended burnup and the front end of the fuel cycle; the impact on fuel performance and in-reactor operation; and the impact on the back end of the fuel cycle.

Fuel failure for water reactors

A consultants meeting was convened to discuss the status of evaluation and collection of fuel failure data. An annual overview of water reactor fuel performance in Agency Member States was recommended to compile information on water cooled fuel behaviour. The preparation of a new, up to date report on the main causes of fuel element failure in water cooled power reactors was also recommended.

QA and QC in water reactor fuel technology

Work started on updating the Agency's Guidebook on Quality Control of Water Reactor Fuel, which was published in 1983 and has served as a comprehensive textbook on this subject. The first draft was prepared and work on the document will continue in 1992.

WREBUS

A report was completed on the technical and economic aspects of an improved scheme of fuel utilization within the framewok of the Water Reactor Extended Burnup Study (WREBUS), which is focused primarily on the assessment of the economics of high burnup operation. The report also assesses the need for higher enrichment and possible fuel design changes and the environmental and licensing implications. Two documents were submitted for publication, one entitled Water Reactor Fuel Extended Burnup Study (in the Technical Reports Series) and Supplement to Water Reactor Fuel Extended Burnup Study (in the IAEA-TECDOC series).

Actinide database

This is the former plutonium database worldwide now extended to the actinides and some fission products. The final report will give an assessment of the cumulative quantity of actinides and the few fission products formed in civilian reactors worldwide up to the year 1990 and the corresponding forecasts to the year 2010. This year was devoted to the establishment of generic models of production by type of reactor. The next task will be to benchmark the results against experience. The results will be used to complete the fuel cycle balance calculations.

WACOLIN

The CRP on Water Chemistry Control and Coolant Interaction with Fuel and Primary Circuit Material in Water Cooled Power Reactors (WACOLIN) is a comprehensive review of the practice and knowledge of water chemistry, corrosion, activity transport and decontamination of water cooled reactors (PWRs, BWRs, HWRs and WWERs). This CRP, which started in 1986, has now been completed and five documents will be submitted for publication.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Technology and performance of burnable absorbers for water reactor fuel (BAF)	1994	10
1990	Grain size determination of zirconium alloys	1992	4

Publications

Series and No.	Title
Technical Reports Series No. 322	Guidebook on non-destructive examination of water reactor fuel
IAEA-TECDOC-584	Guidebook on quality control of mixed oxides and gadolinium bearing fuels for light water reactors
IWGFPT/36	Fuel performance at high burnup for water reactors
IWGFPT/37	Post-irradiation examination techniques for water reactor fuel

Spent fuel management, technology and safety

Regular Advisory Group on Spent Fuel Management

A meeting of the Regular Advisory Group on Spent Fuel Management was held in Vienna to review the worldwide situation with regard to spent fuel management, to define the most important directions of national efforts and international co-operation in this area, to exchange information on the present status and progress in the nuclear fuel cycle, and to assist the Agency in formulating future programmes in this field. The Group observed that the activities related to the management of spent nuclear fuel continue to be of high priority in assuring the optimum safe use of nuclear energy. It was agreed by the participants that past and current activities of the Agency have proved to be very beneficial in assisting countries in matters related to spent fuel management. As the result of this meeting, the 1991 edition of Spent Fuel Management: Current Status and Prospects will be published.

Spent fuel rod consolidation

A report on the status and prospects of LWR spent fuel rod consolidation was prepared with the participation of two consultants and will be submitted for publication. The conclusions contained in it are as follows: As a result of the circumstances prevailing, long term storage can be considered as the most preferable option for the management of spent fuel until well into the next century. Wet and dry storage concepts are regarded as being proven and are expected to be used continuously in the future. Improvements, however, will be made, including the use of rod consolidation, compact racks, double-tier, etc., to increase storage capabilities. Rod consolidation programmes under both wet and dry conditions are in progress in several developed countries.

Partitioning and transmutation of actinides and fission products

In the mid-1970s, the Agency conducted a CRP on the partitioning and transmutation (P&T) of actinides and fission products. Since then, the activities of the Agency in this area have been limited to the separation of selected fission products from high level liquid wastes. However, in recognition of the current interest in the subject area, and also at the request of several Member States, the Agency organized an Advisory Group meeting in October on the partitioning and transmutation of actinides and selected fission products from HLW in order to obtain information on the results of national and international studies on this topic and to obtain advice on possible future Agency activities in this field. Twenty-three participants from 14 countries and 2 international organizations took part in the meeting. The Group observed that there was wide interest among participating Member States in the P&T option as a possible complement to the reference scenarios of the back end of the fuel cycle. It was agreed that current and future activities of the Agency could be very beneficial in assisting Member States in matters relating to the P&T programme and information exchange. The Agency was requested to co-ordinate the activities of non-OECD/NEA and OECD/NEA countries by setting up an advisory body.

Spent fuel storage Safety Series

The structure of Safety Series documents covering all aspects of the storage of spent nuclear fuel was established last year and preparation has begun on two documents on the design and operation of spent fuel storage facilities (Safety Guides) and one on safety analysis reports for spent fuel storage (Safety Practices). For each of the three documents a separate working group was formed. The groups have already had one meeting and have produced the first drafts of their respective documents which were discussed further during an Advisory Group meeting in Vienna. The expected date of completion of the three documents is 1994.

BEFAST-II

The final report of a CRP on the Behaviour of Spent Fuel Assemblies During Extended Storage (BEFAST, Phase II, 1987–1991) was submitted for publication. It contains results on wet and dry spent fuel storage technologies obtained from 16 organizations representing 13 Member States. The report concluded that while wet storage continues to be the preferred method for away from the reactor storage, dry storage is increasingly used for the longer term.

Removal of nuclear materials in Iraq

As a result of Resolution 687 of the United Nations Security Council to destroy or render harmless all nuclear capabilities of Iraq, the Division of Nuclear Fuel Cycle and Waste Management was asked to co-ordinate the removal of fresh and irradiated research reactor fuel from Iraq. This work involved discussions with participants (from France, the United Kingdom and the USSR) on the removal work, contract negotiations and field trips. As a result of the work in November almost all fresh fuels were shipped from the facility to the USSR. Negotiations on the contract for the removal and processing of the irradiated assemblies are under way.

Publications

Series and No.	Title
Technical Reports Series No. 240	Guidebook on Spent Fuel Storage. Second edition
Technical Reports Series No. 321	Management of severely damaged nuclear fuel and related waste
IAEA-TECDOC-627	Catalogue of methods, tools and techniques for recovery from fuel damage events

Radioactive waste management

Code of practice

The General Conference, by Resolution GC(XXXIV)/RES/530, adopted the Code of Practice on the International Transboundary Movement of Radioactive Waste and requested the Director General to monitor implementation by Member States. Pursuant to the resolution, the Director General requested Member States to inform the Secretariat whether they had adopted legislation on the transboundary movement of radioactive waste and, if so, whether it was in accordance with the Code of Practice. About thirty Member States replied that they had adopted such legislation and/or the relevant procedures applicable, though mostly within national boundaries, and that they were generally in accordance with the principles in the Code. Some Members referred to regional agreements concluded on this matter.

International collective opinion

In March 1991, a summary of the 'international collective opinion' was presented by high level experts of the CEC, the OECD/NEA and the Agency. This opinion is a landmark statement regarding the status of the scientific evaluation of radioactive waste repositories and confirmed that safety assessment methods are available to adequately evaluate the potential long term radiological impacts of a radioactive waste disposal system on man and his environment.

Management of spent radiation sources in developing countries

The Agency initiated a five year project to improve safe management of spent radiation sources used in medicine, industry and research. Under the project's action plan, international experts will convene national and regional training courses and conduct field missions to assist authorities in identifying, collecting, conditioning and properly storing spent radiation sources. These efforts are specifically directed at developing countries, where needs are considered most urgent.

Demonstration of treatment and conditioning of radioactive wastes

In line with ongoing efforts to improve the assistance offered to Member States, the Agency's waste management programme has incorporated practical demonstrations of techniques for the immobilization of low level wastes into its waste management training courses. The significance of this new training approach is that it will provide a much needed bridge between theoretical knowledge and practical implementation.

WAMAP

Four regular Waste Management Advisory Programme (WAMAP) missions were conducted in developing Member States in 1991, as well as one special mission to Hong Kong (United Kingdom). WAMAP provided advice on establishing national waste management programmes and systems and technical assistance on specific waste management issues and problems. To date, the Agency has conducted 35 WAMAP missions to 34 countries since the programme was implemented in 1987.

Handling, treatment, conditioning and storage of radioactive wastes

Quality control of high level waste packages

A report was completed providing guidance in assessing the necessary items to control the conditioning process in such a way that waste packages are produced in compliance with the waste acceptance requirements. The document recommends the quality control requirements and methods which should be used in order to contribute to the objective of the safe disposal of high level, heat generating wastes and indicates where and when the control methods can be applied. The emphasis is on the control of the process and little reliance is placed on non-destructive or destructive testing. The report is the first in a series of Agency publications on the quality assurance/quality control of waste packages.

Use of inorganic sorbents

Low cost, high selectivity, high radiation and thermal stability, and a high radioisotope retardation capacity are all factors demonstrating the potential of inorganic sorbents in the treatment of liquid radioactive wastes and as barrier material at repositories. A CRP was initiated on this subject in 1987, bringing together 12 investigators from developed and developing Member States. The research covered naturally occurring and synthetic sorbents and included fundamental studies of sorbent properties and practical applications. A report summarizing the results of the CRP has been prepared and will be submitted for publication. The research studies confirmed that certain inorganic materials are effective as sorbents for radionuclides and can play an important role in the treatment and disposal of radioactive wastes.

Waste minimization

To reflect the increasing concern over the quantities of wastes that are generated, the Agency is developing a report on administrative, technical and procedural options for the minimization of radioactive wastes generated in the nuclear fuel cycle. The parts of the nuclear fuel cycle considered in this document relate to uranium conversion and enrichment, fuel fabrication, nuclear power plant operation and spent fuel reprocessing. Various options available to reduce the volume and radioactivity of low and intermediate level waste streams are summarized in the report.

Advice on waste management for WWER type reactors

The Agency has expanded its activities on the improvement of national radioactive waste management systems and practices in eastern European countries. Co-operation in implementing improved methods and practices for handling and processing radioactive wastes from WWER type reactors has taken place within the framework of a regional project entitled Advice on Waste Management for WWER Type Reactors.

CRPs established in the current year

Subject	No. of years	Participating institutions
Performance of high level waste forms and packages under repository conditions	5	10
Treatment technologies for low and intermediate level wastes generated from nuclear applications	5	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on management of spent sealed radiation sources	Kenya	23	2 weeks
Regional course on management of radioactive wastes from hospitals and other nuclear application activities	Turkey	22	3 weeks
Regional course on national infrastructure for radioactive waste management	Indonesia	20	2 weeks

Publications

Series and No.	Title
Technical Reports Series No. 320	Evaluation of spent fuel as a final waste form
Technical Reports Series No. 325	Particulate filtration in nuclear facilities
Technical Reports Series No. 326	Conditioning of alpha bearing wastes
IAEA-TECDOC-582	Performance of high level waste forms and engineered barriers under repository conditions
IAEA-TECDOC-620	Nature and magnitude of the problem of spent radiation sources

Radioactive waste disposal

Near surface disposal of radioactive wastes

A report reviewing the available options for low level radioactive waste disposal was completed in 1991. It provides descriptions of the different low level waste options used in Member States, identifies the economic considerations of the different options and highlights the important technical elements relevant to the selection of a disposal option.

Deep geological disposal of radioactive wastes

A report was completed on the performance of engineered barriers in deep geological repositories which provides technical information on the performance of materials used for backfill, buffers and seals in geological repositories for the disposal of spent nuclear fuel, when it is considered to be a waste, and solidified high level wastes from the reprocessing of spent fuel.

CRPs established in the current year

Subject	No. of years	Participating institutions
Performance of engineered barriers in near surface disposal facilities	5	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Seminar on storage and disposal facilities for low level radioactive wastes	France	160	1 week

Publications

Series and No.	Title
IAEA-TECDOC-603	Factors relevant to the sealing of nuclear facilities
IAEA-TECDOC-606	Considerations in the safety assessment of sealed nuclear facilities
IAEA-TECDOC-630	Guidelines for the operation and closure of deep geological repositories for the disposal of high level and alpha bearing wastes

Decontamination and decommissioning of nuclear installations

International guidance

A report concerning monitoring programmes for unrestricted release related to the decommissioning of nuclear facilities was approved for publication. Efforts are also under way to prepare another report to provide guidance on planning and management for the decommissioning of research reactors. A report providing an overview of national decommissioning policies is in preparation.

Technology review

In the field of cleanup of large areas contaminated as a result of a nuclear accident, efforts are under way to prepare a document on the decommissioning alternatives for a nuclear reactor after a severe accident.

Uranium mill tailings management

A study is being prepared on factors relevant to the decommissioning of uranium mining and milling facilities and tailings piles. Another report on measurement and calculation of radon releases from uranium mill tailings was approved for publication.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Decontamination and decommissioning of nuclear facilities — phase II	1992	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Course on decontamination and decommissioning	France	23	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 327	Planning for cleanup of large areas contaminated as a result of a nuclear accident

Radiological and environmental aspects of waste management

International exemption levels

Following the issuance of revised ICRP recommendations early in 1991, work has started on updating international standards on radiation protection. The opportunity is being taken to introduce more realistic definitions of radioactive material which can be exempted from regulatory control because it represents a trivial risk to health. The basis for defining these quantities is the OECD/NEA-Agency guidance on exemption principles contained in Safety Series No. 89 and the results of the subsequent application of the principles in the radiation protection and waste management areas. It is now necessary to ensure that proper co-ordination is achieved with other international organizations working in this field so that the promulgation of incompatible values is avoided.

Principles and criteria for waste disposal

Plans for disposing of radioactive wastes have raised a number of unique problems, mainly due to the very long time-scales which have to be considered. While there is general agreement on disposal methods and on many aspects of safety principles, a number of issues remain to be resolved. For example, guidance is needed on the nature of the safety assessments required at different time periods in the future and on possible alternatives to the current safety objectives for waste repositories which are based on limiting radiation risk to humans. In 1991, a forum was established by the Agency to facilitate the discussion of these issues at the international level and to provide a mechanism for establishing a consensus. Experts plan to meet annually to consider topical issues and to discuss and evaluate position papers on previously identified subjects.

London Dumping Convention

The Agency continued to fulfil its role as advisor on radiological matters to the London Convention on the Prevention of Marine Pollution. At the 1991 meeting of the Convention, it was confirmed that the voluntary moratorium on the sea dumping of radioactive waste established in 1983 would continue until the results of the Inter-Governmental Panel of Experts on Radioactive Waste Disposal at Sea (IGPRAD) are made available in 1993, at which time a decision will be taken on the issue. However, there seems little doubt that the voluntary moratorium will be replaced by a prohibition on the sea dumping of all types of radioactive waste.

IAEA-MEL

The scientific objectives of the Monaco Laboratory were widened to include more applied areas of marine radioactivity studies, e.g. radiological assessments, emergency response, marine modelling and database provision, isotopic tracers within the marine carbon cycle and comparative radiological assessments between industries. To more fully reflect the Laboratory's increasing range of interagency activities, i.e. as the only marine environment laboratory within the United Nations system, its name was changed to the IAEA Marine Environment Laboratory (IAEA-MEL). Furthermore, the Principality of Monaco, which hosts and co-funds the Laboratory, indicated its intention to provide new, expanded (3700 m^2) and permanent premises for the Laboratory in a prime site location on the main port. The new Laboratory is expected to be completed in late 1993 or early 1994.

Status of marine intercomparison exercises

Sample description	Status
IAEA-367, coral sediment	Completed (Report IAEA/AL/046)
IAEA-368, coral sediment	Completed (Report IAEA/AL/047)
IAEA-134, Irish Sea cockle	Prepared for distribution 1992
IAEA-135, Irish Sea sediment	Prepared for distribution 1992
IAEA-299, Baltic Sea water	Planned 1992
IAEA-297, Baltic Sea sediment	Planned 1992
IAEA-315, Bombay sediment	Planned 1992

Support for marine radioactivity studies

One of the primary aims of IAEA-MEL is to support marine radioactivity monitoring and research activities for the benefit of Member States. The IAEA-MEL now provides services to over 100 Member State laboratories. During 1991, two radiological intercomparison exercises were completed, and the results published, and a further two samples were prepared for distribution.

Scientists from the IAEA-MEL play a key role in several projects implemented through the Agency's Technical Co-operation programme. These activities generally fall within IAEA-MEL's mandate to develop and enhance the marine radioactivity measurement and assessment capabilities of Member State institutions, and to provide training in radionuclide methodologies and analytical quality control services. A highlight of these activities has been the active response of Member State institutions participating in the Agency's Regional Asian Project on marine contaminant and sediment transport (RAS/8/065). Since sediments and associated contaminants can move with ocean currents, the Agency hopes to encourage adjoining nations to plan and implement co-operative research studies in the region and to promote the use and application of nuclear techniques to assess the source, trend and impact of contaminants on the marine environment.

In addition to research contracts or agreements related to CRPs, the IAEA-MEL financed some 18 individual research contracts concerned with topics ranging from the development and use of nuclear and isotopic techniques to assessments of nuclear and non-nuclear contaminants.

Understanding radioactivity in the marine environment

The IAEA-MEL responded to a request by the Commissariat à l'énergie atomique (Montlhéry, France) to provide personnel to assist in establishing a sampling protocol and to attest to the reliability of the collections, handling, shipment, storage and analyses of samples of sea water and biota from the territorial waters around Mururoa Atoll (French Polynesia). The samples were then distributed to a small group of participants as part of a radiological intercomparison exercise. A report containing a brief outline of the sampling programme and a summary of the radiological data was published in July 1991 (IAEA-AL/044). The final results show very clearly that radioactivity concentrations around Mururoa are extremely low, close to detection limits and generally at global fallout levels. Interestingly, the study produced the first field derived value for the concentration factor (CF) of fallout ^{137}Cs by zooplankton in the open ocean. This new measurement (CF=14) suggests that the previous estimate given in the Agency's Technical Reports Series No. 247 (CF=30) overestimates radionuclide concentration by zooplankton at the lower end of the marine food

Understanding radioactivity in the marine environment (cont.)

chain. Overall, this study is important in confirming on an independent collaborative basis that there is no contamination problem in the marine environment of Mururoa Atoll.

In collaboration with scientists from the Lawrence Livermore Laboratory (USA), IAEA-MEL scientists completed an intercomparison exercise for artificial radionuclides in a group of randomly selected soil samples from Rongelap Atoll in the Marshall Islands. The analysis of dietary samples showed levels of naturally occurring ^{210}Po to be the highest among components of the marine food chain to man. This information and a report on the intercomparison exercise is being prepared for publication.

The European Bank for Reconstruction and Development has funded an important pilot study of nuclear and non-nuclear contamination in the Danube River basin. The primary contractor for the study is the Cousteau Foundation, which has subcontracted to IAEA-MEL for both aspects of the project. Samples of sediment are currently being collected in the region. The radioactivity study involves a comparative assessment of the environmental and radiological impacts of a range of eastern European industries, including fossil fuel power stations, large chemical (phosphates, ores) complexes and nuclear sites in Hungary, Romania and Bulgaria. The measurements combine low level radiochemical analyses on ground samples with aerial radiometric mapping, carried out using large volume gamma spectrometers deployed on a helicopter. This is a very rapid and efficient way of simultaneously mapping natural and man-made radioactivity in the environment.

Global measurements of the vertical flux of radionuclides

In light of the increasing need to understand the carbon cycle and the greenhouse effect, the IAEA-MEL expanded its participation in oceanographic cruises in the Mediterranean Sea to measure the vertical flux and changes in the inventories of radionuclides and other elements, including carbon. The samples analysed were sea water, sediment, plankton and particles collected with sediment traps, in situ pumps and by scuba diving.

Collaboration with French scientists took place in the Ligurian Sea, the Gulf of Lions and the Alboran regions of the Mediterranean Sea. The Laboratory processed numerous sediment trap samples from the DYFAMED time-series station in the Ligurian Sea and found that the vertical flux of carbon shows a strong seasonal signal which is related to the spring plankton bloom in this region. A similar seasonal pulse of the carbon flux was noted in the Gulf of Lions during a flux experiment carried out under the EEC sponsored European River-Ocean Systems Programme (EROS-2000). These two studies have also shown that the particles' transuranium nuclide concentrations are closely related to their carbon contents, thus underscoring the importance of sinking biogenic debris in transporting plutonium and americium to depth in the Mediterranean Sea.

Similar work in the Alboran Sea focused on elucidating the impact of oceanic frontal processes on the fate of sinking particles and the transfer of natural elements through the food web. Very high vertical fluxes were noted in the frontal zone as compared with either side of the front and, as in the other regions, were directly related to prevailing biological productivity cycles. The results of all these studies are important for understanding the distribution and fate of radionuclides and other anthropogenic pollutants in the sea.

Global measurements of the vertical flux of radionuclides (cont.)

Laboratory radiotracer studies have continued to examine the biochemical parameters involved in the process of uptake and assimilation of ingested radionuclides. Emphasis has been placed on small planktonic species which, because of their large biomass in the sea, are primarily responsible for either the recycling of radionuclides that can be assimilated in the upper water column or the excretion of elements that cannot be assimilated and their subsequent transport to depth.

The usefulness of the natural radionuclides ^{210}Po and ^{210}Pb to help delineate feeding habits was examined in an Antarctic food chain. From a detailed comparison of ^{210}Pb in a variety of krill samples, as well as the organisms they ingest, a seasonal variation in ^{210}Pb concentration was found which is presumably related to changes in krill diet. On the basis of a simple classification of the pelagic food chain studied, ^{210}Pb levels increased from omnivores to filter feeders to predators, thus suggesting that, like ^{210}Po, ^{210}Pb also traces dietary changes in lower trophic level species.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Validation of models for the transfer of radionuclides in terrestrial, urban and aquatic environments (VAMP)	1994	17
1990	Safety assessment of near surface radioactive waste disposal facilities (NSARS)	1994	15

Publications

Series and No.	Title
IAEA-TECDOC-588	Inventory of radioactive material entering the marine environment: sea disposal of radioactive waste
GESAMP Reports and Studies No. 48	Coastal modelling

Waste management planning and infrastructure

Waste management information systems

The Waste Management Data Base system became operational in early 1991. The database contains information on waste management activities and plans, operational data, and national policies and regulations. The data are supplied by the respective Member States. A report summarizing the data collected between September 1989 and September 1990 was published.

RADWASS

The Secretariat began development of a new series of Radioactive Waste Safety Standards (RADWASS). This programme will consist of a hierarchy of safety documents, consisting of a single fundamentals category document, six Safety Standards, 17 Safety Guides, and additional Safety Practices documents to be identified as the programme proceeds. Phase I of RADWASS envisages the development of nine of the higher priority documents. Work began in 1991 to prepare eight of these nine documents. Meetings of expert groups were convened in 1991 to draft these eight documents, covering Safety Fundamentals; Safety Standards on pre-disposal management, near surface disposal of radioactive waste and decommissioning of facilities; and Safety Guides on waste classification, siting of near surface disposal facilities and siting of geological disposal facilities. As part of the management scheme for RADWASS, five Standing Technical Committees (STC) with expertise in different waste management subject areas have been established to review draft RADWASS documents. Experts representing 23 Member States and the CEC are participating in these reviews. During 1991, STC meetings were held on disposal, planning and pre-disposal, and a subcommittee of the International Radioactive Waste Management Advisory Committee (INWAC) was convened as a Technical Committee to review the draft RADWASS Safety Fundamentals document.

Publications

Series and No.	Title
IAEA-TECDOC-629	Radioactive waste management profiles: compilation of data from the Waste Management Data Base (WMDB)

Interprogramme activity

Comparative assessment of nuclear power and other energy sources

Senior Expert Symposium

The Senior Expert Symposium on Electricity and the Environment was held in Helsinki, Finland, in May. The symposium was organized jointly by 11 international organizations: the Agency, CEC, CMEA, IEA, IIASA, OECD/NEA, UNECE, UNEP, WHO, WMO and the World Bank. The meeting was hosted by the Ministry of Trade and Industry of the Government of Finland. More than three hundred leading energy experts, from 38 countries and 21 international organizations, took part in the symposium, which provided a comprehensive assessment of the environmental and health issues as well as the technical and economic factors involved in supplying electricity services.

The meeting concluded that the global demand for electricity services will continue to increase, subject only to constraints on economic growth. Improving efficiency throughout the electricity system, from generation to end use, could contribute significantly to reducing emissions and other environmental impacts, but efficiency improvements will not eliminate the need for new electricity supply facilities. In order to meet the widely varying needs of different countries and regions, all technology options should be kept open.

The results of comparative risk assessments of the different energy systems indicate that, under routine operating conditions, nuclear power and renewable energy systems tend to be at the lower end of the spectrum of health risk and that energy systems based on coal and oil are at the higher end. In spite of such assessments, however, the safety of nuclear power, and therefore also its acceptability, continue to be questioned.

It was noted at the symposium that all the major fuel cycles, including nuclear, when fitted with state of the art technology, are able to deliver electricity at relatively low risks to health and the environment. An exception is CO_2 emissions from fossil fuels, and the associated risk of global climate change. In this regard, the symposium concluded that nuclear power is the non-fossil energy source with the greatest potential for use on a large scale at a competitive cost, and that the use of nuclear energy in place of fossil fuels can result in substantial reductions in CO_2 emissions. Renewable energy sources other than hydropower are an essential part of any impact reduction strategy, but are unlikely to meet a large share of the overall electricity demand at the current stage of technological development.

The symposium recommended strengthening of co-ordination and liaison mechanisms amongst the various international organizations with an interest or role in the health, environment and energy sectors, and also called for the establishment of a comprehensive, internationally co-ordinated database on the technical, economic, health and environmental parameters of different energy sources.

Senior Expert Symposium (cont.)

The results of the symposium were presented and discussed in the special scientific programme during the regular session of the General Conference. The results were also presented to the secretariat of the United Nations Conference on Environment and Development (UNCED), with stress on the important role of electricity in both environmental and developmental issues.

Comparative assessments

Work continued on specific aspects of the comparative assessments of nuclear power and other energy sources, in particular with regard to international activities on greenhouse gas emissions and global warming:

- Contributions to the work of the Intergovernmental Panel on Climate Change (IPCC) continued, mainly through participation in meetings of the IPCC Plenary, Working Groups I and III, and the Energy and Industry Sub-Group of Working Group III. Within the framework of the IPCC, the Agency has also participated in meetings of the Intergovernmental Negotiating Committee on a Framework Convention on Climate Change. Agency contributions have been aimed at ensuring the full and objective consideration of the role of nuclear power in relation to global climate change issues.
- The Agency participated in, and chaired, a session on nuclear energy, in the World Clean Energy Conference, held in Geneva in November. Participation in this meeting was useful in helping to ensure a more positive consideration of nuclear energy.
- Co-operation was continued with the World Bank and national development agencies in a project to prepare an environmental data manual.
- Work was completed, with the help of a consultant, on a technical document on the technical and economic potential for renewable sources of energy to contribute to electricity supplies.
- Work was initiated on the preparation of an internationally harmonized reference technology database (TDB) for energy and electricity planning strategies. The TDB will be submitted to the supporting organizations of the Helsinki symposium as a proposal for a joint programme.

Assessment and management of health and environmental risks for energy and other complex industrial systems

There is a growing need to ensure that health, environmental and safety issues are addressed as an integral part of social and economic development. This can be achieved through an integrated approach to risk assessment and management, an initiative being implemented through a joint programme by the Agency, UNEP, UNIDO and WHO. A major highlight of the year was the completion of a draft procedural guide for integrated health and environmental risk assessment and safety management in large industrial areas. The procedural guide is a much needed tool in this field and was reviewed at an international workshop, held in Tel Aviv, Israel, attended by participants representing 22 countries and 5 international organizations. A major achievement was also the publication on a trial basis of a Manual for the Classification and Prioritization of Risk from Major Accidents in Process and Related Industries. The manual represents a novel approach for the identification of priority risk sources in large industrial areas.

Work has also progressed, as part of the programme, on case studies in 15 participating countries. A joint IAEA/UNIDO risk assessment of the Copsa Mica area in Romania has also been undertaken. Two weeks of training on integrated risk assessment and management, within the framework of the programme, was conducted by the Government of The Netherlands to participants from Latvia, Yugoslavia and USSR.

Economic comparisons

Work continued, in co-operation with OECD/NEA, on the comparative fuel cycle costs and the total electricity costs of nuclear and conventional power plants. A report is being prepared for publication in 1992.

Publications

Series and No.	Title
Proceedings Series	Senior Expert Symposium on Electricity and the Environment: key issues papers
Special publication	Electricity and the environment: proceedings of the Senior Expert Symposium
Special publication	Electricity and the environment: executive summary
IAEA-TECDOC-624	Electricity and the environment: background papers for the Senior Expert Symposium

Food and agriculture

Soil fertility, irrigation and crop production

Improving production in salt affected soils

A CRP in progress on the use of nuclear and isotopic techniques to improve crop production on salt affected soils has identified salt tolerant crop genotypes which have the additional benefit of ameliorating the soils. In a study carried out in Nigeria, both millet and sorghum grown in saline soils resulted in a significant decrease in both soil salinity and sodicity (i.e. high exchangeable Na on colloidal constituents of the soil matrix). In similar work conducted in Pakistan, salt tolerant varieties of barley, rice (Basmati 370), wheat and *Sesbania acyleta* grown in salt affected soils ameliorated the soil sodicity. Attempts are being made to improve understanding of plant physiological mechanisms controlling salt tolerance. For example, studies with ^{22}Na in barley varieties grown in salt stress conditions have shown that the salt tolerance of barley is partly due to the selective uptake of K and Na and a lowered shoot to root ratio of Na and Cl. Salt tolerant cultivars of soybean generally avoid buildup of Na in their tissues and accumulate more K than their sensitive counterparts.

Low phosphate and drought prone soils

In another CRP on isotope studies on increasing and stabilizing plant productivity in low phosphate and drought prone soils of the tropics and subtropics, the initial results indicate that there is considerable variation in water and P use efficiency of the crops tested. Of the 24 genotypes of wheat tested in Morocco, Massa and Sarif varieties have been identified as being superior in grain water use efficiency, genotype Zeramek as superior in straw water use efficiency, and the genotypes Kyperouada and Saada as superior in both grain and straw water use efficiency. Of the 16 durum wheat varieties tested in Tunisia, the cultivars Mahoundi, 122 chen "5"/altar 84, Hamira AC1, Razzak and Briskri glabre RP2 have been found to be superior in water use efficiency. Eleven genotypes of cowpea and twenty-one genotypes of maize were screened for high P use efficiency in Sierra Leone, and the results indicated that significant genotypic variations exist in both crops. The research is continuing on the selection of more elite cultivars for high water and P use efficiency, and on detailed studies aimed at finding reasons, both physiological and morphological, for their superiority.

Nitrogen fixation

Co-ordinated Research Programmes on the use of isotopes to improve nitrogen fixation and yield of common grain legumes and trees have shown up to tenfold and more differences in nodulation and N_2 fixed in different cultivars and provenances. Some grain legume cultivars with high yield were not as good in nitrogen fixation as some lower yielding cultivars. A useful strategy now is to combine the high yield abilities of cultivars with those for nitrogen fixation to have cultivars with both high capacity for nitrogen fixation and grain yield. Research is continuing on the beneficial effect of prunings from nitrogen fixing trees on soil fertility enhancement and yield increases of associated food crops.

Irrigation schedules

A CRP on the use of nuclear and related techniques in the assessment of irrigation schedules of field crops to increase effective use of water in irrigation projects was initiated. Excess water application at farm level compounded with seepage water along irrigation networks often causes a rise in the groundwater table, triggering soil salinity problems. It has become a matter of concern in recent years that, despite their high costs, the performance of many irrigation

Irrigation schedules (cont.)

projects has fallen short of expectations as a result of inadequate water management at both farm and system level. Crop production increase has been well below the project targets. The work under this programme aims at improving irrigation scheduling and thereby increasing the effective use of scarce water resources under irrigated agriculture. The programme is based on recently published research work which suggests that exposing field crops to water stress at specific growth stages may not cause significant yield decrease and therefore irrigation during these stages can be omitted and excess water left in the system can be used to irrigate additional areas.

Plant nutrients and water balance

A regional technical co-operation project for Middle East countries on plant nutrient and water balance studies became operational. The participant countries in the project are Cyprus, the Islamic Republic of Iran, Jordan, Saudi Arabia, Syrian Arab Republic, Turkey and the United Arab Emirates. It is expected that Afghanistan will also participate. A workshop within the framework of activities envisaged in the project was held in Damascus, Syrian Arab Republic. During the workshop, the research scientists associated with the planned field experiments received training on the use of isotopes and related nuclear techniques in soil fertility, biological nitrogen fixation and soil water management.

Laboratory activities

The Soil Science Unit of the Agency's Laboratory at Seibersdorf continued to provide technical support to the various programmatic areas.

In connection with nitrogen fixation programmes, work continued on the use of molecular biology techniques in microbial ecology studies. Considerable progress was made in the development of the GUS-gene marker technique, which can be used to identify nodule producing *Rhizobium* bacteria. Research is under way to characterize the newly developed strains prior to the evaluation of their symbiotic performance.

Research on the adaptation of the ^{15}N methodology for measuring nitrogen fixation in tropical trees focused on evaluating a number of ^{15}N soil labelling techniques and testing the suitability of various reference tree species.

To optimize the efficient use of applied P fertilizer by plants, studies on improved management practices and genotypic differences in phosphorus uptake and use by various tree and crop species were carried out.

Investigations continued on the validation of the carbon ($^{13}C/^{12}C$) isotope ratio discrimination technique for the identification of plant genotypes with high water use efficiency. Field work supporting the newly initiated CRP on the use of nuclear techniques in the assessment of irrigation scheduling for increasing irrigation water use efficiency was initiated. The objective of this work was to test the field experimental design which will be adopted in the core experiments to be performed under a new CRP on this topic.

The results emanating from the research carried out in the laboratory were presented at research co-ordination meetings, at international meetings and in scientific journals.

The Unit provided 52 person-months of training to fellows and conducted one interregional training course (19 participants from 18 Member States) on the use of isotope and radiation techniques in studies on soil-plant relationships with emphasis on plant nutrition.

Analytical services, mainly nitrogen isotope ratio determinations, were provided for approximately 15 000 samples in connection with the research contract and

Laboratory activities (cont.)

technical co-operation programmes. Development work was initiated to interface an elemental nitrogen analyser to an improved version of an optical emission spectrometer for simultaneous determination of total N and nitrogen isotopic ratio in biological samples.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Use of nuclear and isotopic techniques to improve crop production in salt affected soils	1993	10
1989	Increasing and stabilizing plant productivity in low P and semiarid and subhumid soils of the tropics and subtropics	1993	14
1990	Management of nitrogen fixation by trees for enhancing soil fertility and soil conservation in fragile tropical soils	1994	14
1990	Use of molecular biology methods in microbial ecology	1994	6
1990	Improvement of yield and N_2 fixation of grain legumes in tropics and subtropics of Asia	1994	11

CRPs established in the current year

Subject	No. of years	Participating institutions
Use of nuclear and related techniques in the assessment of irrigation schedules of field crops to increase the effective use of water in irrigation projects	5	17

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the use of isotope and radiation techniques in soil–plant relationships	IAEA Seibersdorf	17	6 weeks
Regional course on isotope and nuclear techniques in studies on soil–plant relations with emphasis on agroforestry and plant nutrition	Nigeria	20	5 weeks

Publications

Series and No.	Title
Proceedings Series	Stable isotopes in plant nutrition, soil fertility and environmental studies
Newsletter	Soils newsletter, Vol. 13, No. 2 and Vol. 14, No. 1

Plant breeding and genetics

Improvement of local crops

Two large scale regional programmes focused on the improvement of local crops through the use of mutation techniques. Cassava, banana, yam, rice, fonio, pigeonpea and cowpea are targets in a CRP on the improvement of basic food crops in Africa. Plant breeders from Côte d'Ivoire, Ghana, Kenya, Mali, Nigeria, United Republic of Tanzania and Uganda, together with Italian scientists, are working on the improvement of important characters, such as drought and disease tolerance, earliness, grain or tuber quality and lodging resistance.

A technical co-operation project initiated in 1986 is dealing with the implementation of newly developed anther culture methods to accelerate the mutation breeding cycle in many of the important cereals in the Latin America region (such as rice, wheat and barley). In vitro culture facilities were upgraded or newly established, in parallel with an intensive training programme. This project was supported by work in a CRP on the improvement of rice and other cereals through mutation breeding in Latin America. Plant breeders from 12 countries of the region are involved in this activity, in close collaboration with US research workers.

Radiation techniques in molecular genetics

Recent developments in plant molecular genetics have shown that radiation techniques are becoming a very powerful tool in gene identification and mapping and the investigation of gene expression in crop plants. These techniques can also be used to create new molecular markers for use as selection tools to improve the efficiency of plant breeding programmes. A CRP on the induction and application of molecular markers for the improvement of cereals and other seed propagated crops was established. It involves geneticists and breeders from Brazil, China, the Republic of Korea, Pakistan, South Africa, the United Kingdom and the USA.

Laboratory activities

The Plant Breeding Unit of the Agency's Laboratory at Seibersdorf continued to perform the following research and development work on the in vitro mutation breeding system for vegetatively propagated tropical crops: (a) mutation induction and in vitro selection of disease resistance in bananas and plantains; (b) mutation induction and somatic embryogenesis in sugar cane; (c) comparative mutagenesis, e.g. gamma rays, fast neutrons and chemical mutagens in cassava; and (d) mutation breeding to improve environmental stress tolerance in *Azolla*. Molecular biology isotope techniques were applied to the study of DNA typing in bananas and plantains for the assessment of genetic variation.

An interregional training course on the induction and use of mutations in plant breeding was held at the Agency's Laboratory at Seibersdorf for 17 participants from developing Member States. Professional staff of the Unit lectured in national and regional training courses and workshops involving more than 120 participants and provided expert services to the technical co-operation programme. In-service training was provided to 9 fellows (40 person-months) in the use of biotechnology and nuclear techniques in plant breeding. The results of the Unit's research were published in 14 scientific papers and presented at 3 international meetings.

A mutation induction service by gamma irradiation and fast neutrons in seeds, plant propagules and tissue cultures of 42 plant species and 184 cultivars was provided free of charge to 78 institutes in 54 Member States. Work will continue on the use of in vitro mutation technology combined with molecular genetics applied to asexual and vegetatively propagated crops for which improvement by cross-breeding is difficult or impossible.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1986	Use of induced mutations in connection with haploids and heterosis in cereals	1991	17
1987	Improvement of rice and other cereals through mutation breeding in Latin America	1991	13
1987	Use of induced mutation and in vitro culture techniques for improving crop plant resistance to disease	1991	10
1988	Mutation breeding of oil seed crops	1992	17
1988	Improvement of root and tuber crops in tropical countries of Asia	1992	8
1988	In vitro mutation breeding of bananas and plantains	1992	8
1989	Improvement of basic food crops in Africa through plant breeding including the use of induced mutations	1993	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the induction and use of mutations in plant breeding	IAEA Seibersdorf	18	6 weeks
Workshop on breeding for stress resistance in basic food crops in Africa	Nigeria	14	2 weeks
Regional advanced course on use of PCs for field data analysis (ARCAL VII)	Uruguay	14	2 weeks

Publications

Series and No.	Title
Proceedings Series	Plant mutation breeding for crop improvement, Vols 1 and 2
Newsletter	Mutation breeding newsletter, No. 37
Cereal Research Communications No. 17	Use of induced mutations in connection with haploids and heterosis in cereals

Animal production and health

General

Support was provided to national animal production and veterinary institutes to use radioimmunoassay (RIA), enzyme immunoassay (EIA) and DNA probes within the framework of studies designed to improve animal nutrition and reproductive efficiency, as well as the diagnosis and control of animal diseases.

Improving livestock productivity

The process of merging and reorientating programmes in animal nutrition and reproduction into integrated studies on animal production was completed and there are now four regional CRPs and two interregional CRPs dealing with this topic. The basic aim of these programmes is to develop diets and feeding strategies which, through resultant improvements in growth rates and/or reproductive efficiency, increase the amount of meat or milk produced by individual animals. These programmes cover cattle, sheep, goats and camelids and examine the possibilities for using locally available grasses, crop residues and agroindustrial by-products as sources of feed.

The studies conducted to date have clearly demonstrated that cheap locally available feed resources can be used to reduce calving intervals and the period required by animals to reach puberty as well as to increase growth rates and milk yields. These studies also served to highlight and correct poor animal management practices such as inefficient artificial insemination procedures and poor disease control and calf rearing strategies.

In support of these activities, an interregional training course at the Agency's Laboratory at Seibersdorf, and a regional training course in Mexico were held At these courses, over forty participants were taught RIA procedures for reproductive and metabolic hormone determinations, as well as methods for measuring nutritional metabolites.

Diagnosis and surveillance of livestock diseases

Programmes involving the use of standardized FAO/IAEA immunoassay tests and DNA probes for diagnosing animal diseases and monitoring the efficacy of national animal disease control efforts continued in some 50 Member States. Particularly important is the FAO/IAEA/SIDA rinderpest seromonitoring network in Africa. The first phase of this programme demonstrated the value of monitoring for the presence of rinderpest antibodies following the wide scale vaccination of cattle supported by the EEC and the OAU/Inter-African Bureau for Animal Research, the results being used to identify cattle herds which had high levels of immunity and those which were not properly vaccinated. A further major output of FAO/IAEA programmes in disease diagnosis was the successful field validation of new immunoassay tests for trypanosomiasis. This research has clearly demonstrated that such tests are on average five times more sensitive than currently available diagnostic tests, paving the way for much more precise monitoring of tsetse and trypanosomiasis control programmes in Africa and elsewhere. Also, through a programme involving Latin American and Asian countries, immunoassay and DNA probes were validated and found to be substantially more specific and sensitive than conventional methods for the diagnosis of brucellosis, leukosis, pseudorabies and bluetongue.

Similar tests for other diseases, such as foot-and-mouth, babesiosis, and Newcastle's disease are currently under validation, and computer software programs for analysing immunoassay test results were developed and counterparts trained in their use.

Symposium

A symposium on isotope and related techniques in animal production and health attracted over 150 participants from 41 Member States. The proceedings contain authoritative and state of the art reviews on the use of isotopic methods in animal nutrition, particularly from the standpoint of developing diets and feeding strategies for improving the nutrition of animals in tropical and subtropical countries. Considerable emphasis is also given to the role of hormone measurements by radioimmunoassay for studying animal reproductive processes and ways of improving reproductive efficiency in developing countries, and to the role of enzyme immunoassay methods for diagnosing animal diseases and monitoring disease control programmes. The proceedings also include several reviews on isotopic methods in molecular biology — particularly the role of these methods in disease diagnosis and the development of new vaccines.

Laboratory activities

The Animal Production Unit of the Agency's Laboratory at Seibersdorf continued to provide technical support, primarily through the production and distribution of standardized and validated clinical and diagnostic kits. Radioimmunoassay kits for the measurement of the reproductive hormone progesterone in milk and blood were distributed to approximately seventy counterpart laboratories. Colorimetric, RIA and selective ion kits for the measurement of eight metabolic parameters were developed and are in the process of final standardization and validation. They will be used to assess and monitor the nutritional status of indigenous livestock species. Approximately 110 enzyme linked immunosorbent assay kits (equivalent to 0.6 million assay units) for the diagnosis of infectious diseases were provided to institutes in Africa, Asia and Latin America, with priority given to six major diseases: rinderpest, brucellosis, foot-and-mouth disease, babesiosis, trypanosomiasis and bluetongue.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Improving the diagnosis and control of trypanosomiasis and other vector borne diseases of African livestock using immunoassay methods	1993	13
1988	Improving the productivity of indigenous African livestock using radioimmunoassay and related techniques	1993	14
1988	Strengthening animal reproduction research in Asia through the application of immunoassay techniques	1993	12
1988	Strengthening animal disease diagnosis in Asia through the application of immunoassay techniques	1993	12
1988	Development of feeding strategies for improving ruminant productivity in areas of fluctuating nutrient supply through the use of nuclear and related techniques	1992	19
1989	Development of feed supplementation strategies for improving ruminant productivity on smallholder farms in Latin America through the use of immunoassay techniques (ARCAL III, Phase II)	1994	21
1990	Serosurveillance of rinderpest in Africa	1995	23
1990	Immunoassay methods for the diagnosis and epidemiology of animal diseases in Latin America	1995	26
1990	Interregional network for improving the productivity of camelids	1995	20

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on immunoassay and related techniques in the study of livestock production in the tropics	IAEA Seibersdorf	21	5 weeks
Regional course on immunoassay and related techniques in livestock reproduction and nutrition research in Latin America	Mexico	28	3 weeks
National course on immunoassay methods for the diagnosis of animal diseases	Chile	16	2 weeks

Publications

Series and No.	Title
Proceedings Series	Isotope and related techniques in animal production and health
Panel Proceedings Series	Isotope aided studies on goat and sheep production in the tropics
IAEA-TECDOC-623	The sero-monitoring of rinderpest throughout Africa — phase one
Newsletter	Animal production and health newsletter, Nos 13 and 14

Insect and pest control

Fruit flies

The medfly is a significant pest of fruit production in the western portion of North Africa. A programme known as 'Maghrebmed' is being implemented in three phases. In 1991, the first phase, an assessment of the economic and environmental burden of the pest, reached its full momentum. Direct costs to the agricultural economies from the medfly have been found to exceed $30 million per year. In addition, the heavy use of insecticidal sprays against the pest appears to have weakened the populations of the complex of beneficial insects that previously controlled other pests. Thus problems with scale insects, aphids, whiteflies and mites on citrus have been greatly exacerbated by spraying against the medfly. In addition, such spraying is causing an as yet unquantified reduction of pollination and incidences of poisonings of agricultural workers.

In order to delimit the areas where the medfly can survive the whole year round, trapping networks have been installed in Algeria, the Libyan Arab Jamahiriya, Morocco and Tunisia, and climatic and phenological data are being assembled. Each country has been provided with a computer and specially written software to manage the vast quantities of data that are being collected. This information will be used to identify options for planning trials of various technologies for clearing the pest from important zones of agricultural production. The aim is to enable the countries involved to meet more adequately the nutritional needs of their growing populations as well as export fruit to overseas markets.

Tsetse flies

A consultants meeting considered the subjects of engineering systems analysis and production modelling for tsetse mass rearing and the use of sterile flies in eradication programmes. The consultants elaborated an approach that is already resulting in more efficient production of tsetse flies. They recommended that a modular design for mass rearing facilities be adopted. These recommendations will prove very helpful as efforts are made to establish regional mass rearing facilities for programmes to meet the tsetse–trypanosomiasis plague in Africa.

Significant progress is being made in combating tsetse on the island of Zanzibar by means of the sterile insect technique (SIT). Also, the reinvasion of the tsetse-free area in Nigeria has been largely forestalled by the release of sterile males and the use of insecticidal cloth targets that selectively attract and destroy tsetse flies.

New World Screwworm

The New World Screwworm is a mortal enemy of warm blooded animals, including humans. In recent decades the sterile insect technique was developed and used to eradicate this parasite from the USA and Mexico. The introduction of this pest into the Libyan Arab Jamahiriya in 1988 and its successful colonization in this new environment far from its original habitat in the Americas represented an alarming development. The parasite presented a very serious threat to wildlife, livestock and people throughout Africa, the Middle East and southern Europe. Consequently, the IAEA, FAO, IFAD, UNDP and the governments of North African countries (especially the Libyan Arab Jamahiriya) organized a campaign against it. The pivotal requirement was to transport millions of sterile flies each week from the only mass rearing facility in existence at Tuxtla Gutiérrez, Mexico, and to distribute them over the infested zone.

New World Screwworm (cont.)

Every effort was made to launch an overwhelming attack against the wild population in North Africa during the winter, when the parasite had little capacity to resist. This strategy proved to be highly successful. Only six cases of infested animals were found in 1991 — compared to 12 068 in 1990 — and the last case was found on 7 April 1991. Releases of sterile flies were continued until mid-October and intensive surveillance will continue until June 1992. At this time there is no evidence to suggest that any of the parasites have survived.

Moths and caterpillars

Caterpillars and other worms belonging to the order of moths are very destructive pests of many crops. The cotton leafworm and the pink bollworm are scourges of cotton production. The diamondback moth, cabbage looper, cutworms and armyworms are major pests of vegetable production. These species have proved to be difficult to control by means of the SIT because they are very radiation resistant and because they are much more difficult to mass rear than flies. However, solutions to these difficulties have emerged. The radiation resistance of these pests is used to good advantage in the so-called F-1 or inherited sterility technique. In a CRP which was completed in 1991, scientists in a number of developing countries adapted this technology to insects of importance in their areas. A new programme that aims at implementing the combined use of natural enemies of the diamondback moth and inherited sterility is being developed in Malaysia.

Laboratory activities

Sexually sterile fruit fly females in their attempt to lay eggs make punctures in the peels of fruit through which organisms which cause rotting enter. It is therefore best to release only sterile males. At the Agency's Laboratory at Seibersdorf, genetic methods for removing female medflies, based on the differential temperature sensitivity of male and female embryos, were improved. The stability of genetic sexing strains was dramatically increased as a result of cytogenetically mapping the two sexing genes, *white pupa* and *temperature sensitive lethal*, and the determination of the Y-autosome breakpoints of 21 new, radiation induced translocation strains. Breakdown was reduced by a factor of one thousand and is now less than 0.02%. Consequently, several new sexing strains were tested for their performance under mass rearing conditions. Since the results were positive, they will be tested for efficacy in the field.

The dynamics and adult behaviour of genetic sexing medfly strains in large mass rearing cages were studied to improve the efficiency of the rearing process and the performance of the flies when released in the field.

Many new isolates of the entomopathogen *Bacillus thuringiensis* were obtained from soils and tested against adult medflies as potential substitutes for insecticides now used to reduce wild populations preparatory to the release of sterile males. The insecticidal agents produced by the most active isolates are being characterized and tested for mammalian toxicity.

Colonies of six economically important tsetse fly species were maintained to: (1) produce insects for technical co-operation projects in African Member States (almost one million pupae were air freighted to BICOT, a tsetse fly control project using the SIT in central Nigeria); (2) provide live or preserved insects for research workers in 18 institutes of 6 Member States; and (3) provide live material for in-house research. The search for sex related differences among immature stages was pursued. The receptivity to mating of radiation sterilized virgin females was investigated. Females produced and sterilized at a mass rearing facility can act as sensitive indicators when released for detecting the

Laboratory activities (cont.)

existence of low level fly populations that may have survived an eradication campaign.

Materials were developed and tested for their biological suitability as transport and release containers to provide an alternative, backup, aerial release method for distributing sterile screwworm flies in North Africa. The repellency of candidate insecticides for use in bait stations was also determined.

Twenty-three person-months of training was provided to fellows and cost free interns. In addition to insects, freeze dried diet components and equipment for insect rearing were provided to technical co-operation projects in Africa and collaborative research institutions in many countries.

Contributions were made to the screwworm eradication campaign by studies on the feasibility of long distance shipments, the adaptation of methods to measure the quality of flies, assistance in the calibration of sensors to record the temperature, humidity and vibration conditions experienced by the flies during each shipment, the derivation of protocols for long term storage of pupae and adults, and the development of alternative techniques for dispersing adults for use if finances should prove to be insufficient to send the sterile flies from Mexico already boxed. In addition, studies were conducted on the responses of adult screwworms to various colours and to contact with insecticides. Such studies were needed to develop the bait station, for improving the performance of the wind oriented trap and for contributing to the development of pour-on treatments to kill females visiting wounds.

The genetic and behavioural compatibility of screwworms indigenous to the Libyan Arab Jamahiriya with those brought from Mexico was tested. Also, maps of the target zone based on Landsat and Spot data with a scale of 1:50 000 were procured and delivered to facilitate the identification of areas that warrant special surveillance. A research contract was funded to develop additional options for chemical control of adults and larvae. Finally, experts from the Natural Resources Institute and the Natural History Museum, United Kingdom, were engaged to conduct studies that might lead to improving the efficiency of the adult trap and bait station.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Standardization of medfly trapping for use in sterile insect technique programmes	1992	9
1987	Radiation induced F-1 sterility in Lepidoptera for area wide control	1992	11
1988	Laboratory and field evaluation of genetically altered medflies for use in sterile insect technique programmes	1993	13
1989	Development of practices for area wide tsetse eradication or control with emphasis on the sterile insect technique	1994	14
1989	Genetic engineering technology for the improvement of the sterile insect technique	1994	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
FAO/IAEA seminar for Africa on animal trypanosomiasis: tsetse control, diagnosis and chemotherapy using nuclear techniques	Kenya	56	1 week
Regional course on the sterile insect technique and F-1 sterility for insect control	Malaysia and Japan	21	4 weeks

Publications

Series and No.	Title
Panel Proceedings Series	Insect disinfestation of food and agricultural products by irradiation
Newsletter	Insect and pest control newsletter, No. 46

Agrochemicals and residues

General

The programme in this area concentrates on studies of the fate, behaviour and effects of pesticides in food and the environment and on the development of improved delivery systems, particularly by means of formulations which control the rate of release of the pesticide in some way.

Pesticide residues in food and the environment

Two of the seven CRPs in progress at the beginning of the year were completed. The most significant conclusion from the programme concerned with pesticide residues bound to biological substrates is that, although in many situations they are of no biological significance, residues of organophosphorus insecticides bound in grain can reduce cholinesterase levels by up to 40% in animals that consume the grain. The enzyme cholinesterase is critical for mammalian nerve function so reductions at this level are of potential toxicological significance.

Work in the other completed CRP has identified four insecticides with potential for use in rice-fish systems in that they can be used without danger to fish and the extractable residues in rice and fish were acceptable. Studies with ^{14}C labelled compounds, however, showed that bound residue levels could be high enough to justify study of their bioavailability.

An important finding in an ongoing CRP is that DDT dissipates 4–30 times faster in tropical environments than in temperate regions. This suggests that the use of these compounds may be acceptable in the tropics, at least in some circumstances. The result gives added impetus to a complementary CRP in which the effect of organochlorines on tropical agroecosystems is being studied.

Laboratory activities

The Agrochemicals Unit of the Agency's Laboratory at Seibersdorf provided 18 person-months of training to fellows and cost free interns in the use of radioisotope techniques in research on agrochemicals. The scientific staff of the Unit participated in research in support of the CRPs on: (1) the development of controlled release formulations of pesticides utilizing nuclear techniques; and (2) effects on flora and fauna of the use of organochlorine pesticides on the African continent.

Other activities included the development of corn oil based formulations of pyrethroid insecticides containing an ultraviolet absorbing compound for use on target screens in the integrated control of tsetse flies in Africa. Deltamethrin formulations continued to kill tsetse flies after 120 days in the field in Kenya. In the United Republic of Tanzania, these formulations killed 85% of tsetse flies after 175 days of field exposure. Results of this research were presented at an FAO/IAEA Seminar for Africa held in Nairobi, Kenya, during February. Two papers related to this topic were accepted for publication in scientific journals.

Research on controlled release formulations of thiobencarb and butachlor herbicides for use in paddy rice continued and several controlled release formulations were tested in China, Hungary, Malaysia, Pakistan and the Philippines. Compared with commercial formulations, the controlled release formulations gave better weed control and were less toxic to rice seedlings and to fish, with the result that the yield of rice grain was higher. Two papers on this topic were accepted for publication in scientific journals.

An insecticide containing bait station was developed as a component of the screwworm eradication programme in North Africa. The bait station should also be useful in other areas.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of controlled release formulations of pesticides utilizing nuclear techniques	1993	15
1989	Radiotracer studies of the behaviour of DDT in tropical environments	1994	14
1989	Radiotracer studies to reduce or eliminate pesticide residues during food processing	1994	13
1990	Adverse effects on flora and fauna from the use of organochlorine pesticides on the African continent	1995	15

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of procedures to stabilize acaricides in livestock dips and of simplified methods to measure their concentration using nuclear techniques	5	7

Food irradiation

ICGFI

The International Consultative Group on Food Irradiation (ICGFI) has continued to provide information and advice to FAO, the Agency and WHO and their Member States in the areas of the safety assurance of the irradiation process and of irradiated foods, techno-economic feasibility, training, regulatory control of food irradiation and public information. The ICGFI Network for Training on Food Irradiation (INTFI), which took over the functions of the previous International Facility for Food Irradiation Technology (IFFIT), held several training courses and workshops. In an effort to provide member countries with accurate information on food irradiation, ICGFI published a series of 14 Fact Sheets on various issues of interest to the public. The Fact Sheets were widely disseminated and were well received by governments, industry, consumer organizations and the mass media. A Task Force on irradiation as a quarantine treatment of fresh fruits and vegetables was convened in early 1991 to evaluate the effectiveness of irradiation, in comparison with other methods, as a quarantine treatment. The Task Force concluded that irradiation is the most viable treatment against major quarantine pests such as fruit fly and mango seed weevil. A minimum dose of 0.15 kGy can be used as a quarantine treatment against fruit fly without adversely affecting the quality of most host commodities.

Technology transfer

Assistance in terms of technology transfer on food irradiation was provided to a number of developing countries in different regions. Through technical assistance programmes, assistance was given to Bangladesh, Peru and Viet Nam in building demonstration irradiators for treating food and sterilizing medical supplies. Expert assistance on the techno-economic feasibility of food irradiation was provided to Bolivia and Costa Rica. Under the UNDP funded Asian Regional Co-operative Project on Food Irradiation, 12 countries are participating in a CRP with emphasis on process control and acceptance of the technology. Two other CRPs are assisting developing countries in Africa, Europe and the Middle East on the use of irradiation to reduce food losses, ensure the hygienic quality of food and facilitate wider food trade.

Public information

To assist national authorities and the public to have factual information concerning the safety, benefits and limitations of irradiated food, two workshops on public information on food irradiation were organized. The first was convened in Bangkok, Thailand, for one week in May for the benefit of journalists and representatives of national consumer organizations in ten Asian countries. The second was held in Karlsruhe, Germany, for journalists from European countries. Articles were later published by the journalists on the basis of information received at the workshops. The Fact Sheets which were published by ICGFI provided important background information.

Practical application

Three additional irradiators became available for processing food and other products during 1991: a commercial ^{60}Co irradiator at Isigny-sur-Mer, France; a large demonstration ^{60}Co irradiator in Hanoi, Viet Nam; and a pilot electron accelerator in Wlochy, near Warsaw, Poland. These bring the total number of irradiation facilities available for food processing to 50. The first commercial food irradiator in North America is expected to be in operation by the end of 1991. Two other commercial food irradiation plants are about to be built in Algiers and Brazil. Favourable reports of marketing trials of irradiated food were received from: Bangladesh (onions and pulses); China (apples, seasonings

Practical application (cont.)

and meat containing irradiated seasonings); the Philippines (onions and garlic); and the USA (strawberries). These trials, together with those conducted earlier, showed that consumers will buy irradiated food once they are aware of its benefits.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Food irradiation programme for Middle East and European countries	1993	11
1989	Application of irradiation techniques for food processing in Africa	1993	10
1990	Analytical detection methods for irradiation treatment of foods	1994	24
1990	Food irradiation process control and acceptance in Asia	1993	16
1990	Irradiation in combination with other processes for improving food quality	1995	19

CRPs established in the current year

Subject	No. of years	Participating institutions
Irradiation as a quarantine treatment of mites, nematodes and insects other than fruit fly	5	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
FAO/IAEA/ICGFI workshop on electron accelerators for food irradiation	Poland	11	2 weeks
FAO/IAEA/ICGFI group training on food irradiation technology	Canada	15	5 weeks
UNDP/FAO/IAEA workshop on public information on food irradiation	Thailand	16	1 week
FAO/IAEA training course on food irradiation technology	Egypt	20	4 weeks
FAO/IAEA/ICGFI workshop on techno-economic feasibility of food irradiation	Bangladesh	20	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-585	Regulations in the field of food irradiation
IAEA-TECDOC-587	Analytical detection methods for irradiated foods — a review of the current literature
Newsletter	Food irradiation newsletter, Vol. 14, No. 2 and Vol. 15, Nos 1 and 2

Human health

Nuclear medicine

Symposium

A symposium on radioimmunoassay and related procedures in developing countries was held in August and attended by 66 scientists from 33 countries. The main themes were methodological developments, reagent production, nuclear techniques for the early detection of cancer, clinical applications, data processing and quality control, and comparison of nuclear and non-nuclear analytical methods. The symposium identified new areas to which radioimmunoassay methods could be applied in developing countries. It emerged from the presentations and discussions that the methods are gaining an even wider popularity and acceptability as diagnostic and research tools.

Promoting research in developing countries

Two CRPs were completed during the year. The first related to the optimization of bulk reagent based methods for radioimmunoassay (RIA) of thyroid hormones. The programme helped to promote good RIA practices, awareness and commitment to quality control measures, progress towards self-sufficiency in reagent supply and close collaboration among the research institutions involved. The second programme related to the immunoradiometric assay method for the diagnosis of tuberculosis. The results showed that this method, while having high sensitivity for the diagnosis of tuberculosis, showed low specificity. It could not therefore be recommended as a routine laboratory test in hospitals.

A CRP on radioaerosol inhalation imaging for the diagnosis of respiratory diseases was to be completed in 1991 but was extended for one more year to examine specifically the effects of atmospheric air pollution on the lung permeability function. The atlas on radioaerosol lung imaging is expected to be published in 1992.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Development and field application of nuclear techniques in malaria research and control (AFRA)	1992	11
1987	Radioaerosol inhalation imaging in the diagnosis of respiratory diseases in developing countries (RCA)	1992	10
1987	Optimization of nuclear techniques for the survey of thyroid function of new-borns in endemic goitre areas	1992	8
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1992	6
1988	Basic care and preventive maintenance of nuclear medicine instruments (RCA)	1992	11
1989	Immunoradiometric assay for malaria detection	1992	7
1989	Evaluation of imaging procedures for the diagnosis of liver diseases: phase II	1992	13
1989	Quality control and preventive maintenance of nuclear and related equipment in Africa	1992	7
1989	Quality control and preventive maintenance of nuclear medicine equipment in Latin America	1992	14
1989	Quality control of advanced nuclear medicine equipment in Asia	1992	8
1991	Diagnosis of tuberculosis using ^{32}P labelled DNA probes (RCA)	1994	9
1991	Detection of blood borne diseases using ^{32}P labelled DNA probes	1994	8
1991	Measurement of alpha-feto protein by RIA in the discrimination of liver space occupying lesions	1993	10
1991	Early detection of colonic cancer by immunoscintigraphy using ^{99}Tc labelled anti-carcinoembryonic antigen monoclonal antibodies	1993	10
1991	Establishment of screening programmes for neonatal hypothyroidism based on filter paper blood spot assays for thyroxine and thyrotrophin (ARCAL VIII)	1993	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on nuclear medicine	Germany	24	4 weeks
Regional course on diagnosis of hepatitis B by RIA (RCA)	China	17	11 days
National course on quality control of nuclear medicine instruments after repair	Malaysia	20	2 weeks
Four national courses on quality control of gamma camera SPECT system	China	80	4 courses of 1 week each

Publications

Series and No.	Title
IAEA-TECDOC-602	Quality control of nuclear medicine instruments 1991
IAEA-TECDOC-613	Nuclear and related techniques in the control of communicable diseases

Applied radiation biology and radiotherapy

Assistance to developing countries

The emphasis in the area of applied radiation biology and radiotherapy centred on strengthening indigenous skills in the developing countries in the use of radiation techniques and technology for upgrading health care services and standards. The local economical provision of radiation sterilized prepackaged medical supplies in patient ready forms was promoted to help sustain safe health care free from the risk of cross-infection in the developing countries of Africa and Latin America. Research support through a regional CRP for Latin America has further helped towards the development of technical criteria for the estimation of microbiological quality and degree of sterility of local radiation processed medical supplies. Draft guidelines on sterility quality assurance for medical products in Latin America were outlined at an Advisory Group meeting.

Chernobyl accident effects

Radiobiology principles were used in the development of criteria for assessing the carcinogenic risks from a potential beta radiation dose from hot beta particles inhaled from the Chernobyl fallout. A standardized protocol for a work programme was developed.

The services of the participants in the CRP on chromosome based biological monitoring were made available in response to a request by the organizers of the International Chernobyl Project.

Low doses and low dose rates

A new CRP with the participation of 12 scientific investigators from 9 developing and developed Member States aims at improving understanding of the molecular mechanisms involved in the biological effects of low doses and low dose rates of ionizing radiation. Another CRP on the comparative assessment of mutagenic and carcinogenic effects of low level radiation and toxic chemicals released from energy cycles was approved. This will help promote the development of quantitative radiobiological criteria to enable an equivalent carcinogenic risk assessment of chemical pollutants from fossil energy cycles to be made and the results compared with the potential risks from low dose radiation.

Radiotherapy

Continued emphasis was placed on promoting the use of radiation energy for the treatment of malignant diseases, especially in developing countries where the incidence of cancer is increasing. About 60% of all cancers are known to require radiation treatment at one stage or another. Only 35% of developing countries have radiotherapy facilities, a majority of which are very poorly equipped. The situation is much worse in Africa and Latin America. There are 24 ongoing radiotherapy projects under the technical co-operation programme aimed at improving or developing radiotherapy facilities. Such projects include the provision of equipment for teletherapy and brachytherapy, manpower training and development and the provision of expert services.

A new CRP on computer assisted planning and dosimetry in the radiation therapy of head and neck cancers was initiated. A second regional CRP on carcinoma of the uterine cervix in the Asia and Pacific region is continuing, while preparatory work is being carried out on a new CRP on brachytherapy techniques for malignant tumours at various anatomical sites.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Microbiological quality control and sterility safety evaluation in radiation sterilization of local medical supplies in Latin America	1994	7
1990	The radiological impact of hot beta particles from the Chernobyl fallout — risk assessment	1993	12
1990	Exploration of the molecular mechanisms of the stimulatory effect (i.e. adaptive response) of low dose and low dose rate radiation	1993	12
1990	Computer assisted planning and dosimetry in radiotherapy of carcinoma of the cervix in the Asia and Pacific region (RCA)	1993	9
1990	Computer assisted planning and dosimetry in radiotherapy of head and neck cancers	1993	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
New approaches in radiation sterilization of medical supplies (regional for Latin America)	Argentina	16	2 weeks
Irradiation processing with particular regard to radiation sterilization of medical supplies (AFRA III)	Egypt	8	4 weeks

Publications

Series and No.	Title
IAEA-TECDOC-614	Organization and training in radiotherapy for developing countries in Africa

Dosimetry

SSDLs

The IAEA/WHO Network of SSDLs now includes 64 laboratories in 51 Member States and 14 affiliated members (primary standard laboratories). Another four SSDLs which have been fully supported are not yet members of the network. Services continued in the areas of dose intercomparison and assurance, as well as support for technology transfer.

Technical support

Support was provided for setting up SSDLs and for improving technical performance as reference standards. Considerable improvements were achieved in measurement accuracy in dosimetry practices and in the provision of calibration services at the national level. A total of 49 technical co-operation projects were handled.

Dose intercomparison and assurance

In connection with the programme to assist Member States in the improvement of accuracy in radiotherapy, the IAEA/WHO thermoluminescent dosimetry (TLD) service was continued and 450 sets of dosimeters were distributed to 60 SSDLs and 280 radiotherapy centres. The International Dose Assurance Service (IDAS) for radiation processing facilities was continued, with 31 participating institutions from 23 countries. The quality control of radiation processing dosimetry was significantly improved.

Development of dosimetry techniques

The national institutes of nine Member States participated in efforts to co-ordinate methods of improving high dose electron dosimetry, to reduce measurement uncertainty and develop new dosimetry techniques. A preliminary dose intercomparison has been completed for evaluation.

Dosimetry laboratory at Seibersdorf

The Dosimetry Unit of the Agency's Laboratory at Seibersdorf, as the central laboratory of the IAEA/WHO network of SSDLs, dealt with service requests for routine dose intercomparisons for hospitals and SSDLs worldwide, calibration of secondary standard dosimeters/field instruments, reference irradiations, development of intercomparison methodologies and training of fellows and scientific visitors. The Unit's activities increased as a result of the introduction of the alanine/ESR dosimetry system for dose assurance measurements at industrial irradiators and the expansion of the TLD dose intercomparison service for hospitals to photon beams from medical accelerators. In addition, active participation in two CRPs was initiated to help convert Agency programmes into regional/national responsibilities (establishment of a quality assurance network based on TLD postal dose intercomparison measurements).

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of quality control dosimetry techniques for particle beam radiation processing	1993	9
1988	Testing of the code of practice for absorbed dose determination in photon and electron beams	1991	9
1989	Performance testing of dosimetry equipment	1993	8

CRPs established in the current year

Subject	No. of years	Participating institutions
Therapy level dosimetry with alanine/ESR system	4	5

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on dosimetry in radiotherapy	Czechoslovakia	15	15 days
Interregional seminar for Europe, the Middle East and Africa on radiotherapy dosimetry: radiation dose in radiotherapy from prescription to delivery (IAEA/ESTRO)	Belgium	87	5 days
Regional course on dosimetry in radiotherapy, including treatment planning	Egypt	49	3 weeks

Publications

Series and No.	Title
Proceedings Series	High dose dosimetry for radiation processing
Newsletter	SSDL newsletter, No. 30

Nutritional and health related environmental studies

Nutrition

The most important project completed during the year — part of the International Chernobyl Project — was an assessment of the nutritional status of persons living in the USSR in regions affected by the Chernobyl accident. Data were collected on more than 1200 persons, and approximately 700 samples were analysed for a variety of essential and toxic elements (many of these analyses were carried out in the Agency's Laboratory at Seibersdorf). The most important conclusions were that: (1) there were no detrimental effects on growth resulting from voluntary or official dietary restrictions imposed as a result of the accident; (2) there were no significant differences in the growth of children in control and contaminated settlements (both were well within published USSR and US norms); (3) iodine intakes and excretion were at the low end of the acceptable range, but apparently not low enough to be causing goitre or other thyroid abnormalities; (4) dietary intakes of toxic elements (lead, cadmium, mercury) were low in comparison with those in many other countries; (5) blood lead levels were well within the normal range (similar observations were made for levels in environmental biomonitors, e.g. lichen); and (6) exposure to organic microcontaminants was acceptably low.

A global database on human daily dietary intakes of nutritionally important trace elements was completed and the results were prepared for publication in the report of the WHO/FAO/IAEA Expert Consultation on Trace Elements in Human Nutrition.

Environment: non-radioactive inorganic pollutants (terrestrial)

Advisory missions on nuclear techniques in environmental monitoring and research were carried out in Chile, Costa Rica, Kenya and Mexico.

Laboratory activities

The Chemistry Unit of the Agency's Laboratory at Seibersdorf continued to provide support for the various CRPs in this subject area and also assisted the WMO Background Air Pollution Monitoring Network (BAPMoN) by acting as a sample collection, data acquisition and distribution centre.

The programme on the monitoring of accidentally released radionuclides in environmental and food samples, which was initiated by the Agency in 1986 in response to the Chernobyl accident, was continued. Support was provided for 11 ongoing technical co-operation projects. A new analytical method for the determination of ^{90}Sr was developed and more than two hundred different environmental samples were analysed for radionuclides, uranium and plutonium. Two analytical reference materials for radionuclides were certified as the result of intercomparison runs.

Staff from the Unit provided laboratory training in low level radioactivity separation and measurement techniques to fellows and to scientific visitors in a study of the determination of natural and man-made radionuclides in food chains and environmental samples (approximately 25 person-months).

Measurements of Chernobyl samples are being completed in conjunction with scientists from other countries. Within the International Chernobyl Project, the Unit organized intercalibration exercises for the analysis of radionuclides by 30 Soviet laboratories.

Staff of the Unit organized the first international symposium on biological environmental specimen banking at Agency's Headquarters in September. The

Laboratory activities (cont.)

meeting was funded by the German Ministry of the Environment, Nature Protection and Nuclear Safety and the US Environmental Protection Agency and held in co-operation with the US National Institute of Standards and Technology. The meeting reviewed the latest concepts in specimen banking, dealing with the type of specimens, sampling, standardization and storage for monitoring environmental pollution and policy. The papers are to be published in the open literature.

Environment: non-radioactive inorganic pollutants (marine)

The IAEA-MEL continued its collaboration with UNEP and IOC of UNESCO for the provision of comprehensive technical support for regional and global marine pollution assessments. During 1991, this work included 33 technical missions to 20 countries in the Mediterranean, Persian Gulf, Wider Caribbean and Black Sea regions, the production of reference methods and materials, two worldwide intercomparison exercises and the training of 35 technical staff from 15 countries in pollutant measurement techniques.

As in previous years, an instrument maintenance service continued to operate for institutions in Mediterranean and African countries and, for the first time, a service training course was given for instrument users from three Mediterranean countries. Staff from IAEA-MEL also provided technical assistance to other agencies for the development of new international marine pollution programmes.

Work on the Caribbean Environmental Programme for Pollution (CEPPOL) for assessing and controlling marine pollution in the Wider Caribbean was completed in September. Efforts are now focused on the Black Sea, where initial technical missions in co-operation with UNEP, UNDP and the World Bank revealed an urgent need for concerted international action to stem the present catastrophic degradation of the marine environment.

Environmental consequences of the armed conflict over Kuwait

In January 1991, at the height of the armed conflict over Kuwait, all United Nations organizations were requested to co-operate in a plan of action to assess the environmental consequences of the war. IAEA-MEL played an integral role in the United Nations Interagency Plan of Action in the Gulf, which was initiated immediately after the cessation of the war in the region. By October 1991, the initial phase of the work was completed. Staff of IAEA-MEL had conducted sampling missions to Kuwait, Bahrain, Saudi Arabia, the United Arab Emirates and Oman. Samples had been analysed for petroleum hydrocarbons and a wide range of heavy metals (using the inductively coupled mass spectrometer) and stable and radioactive isotope tracers. Initial results suggested that the war related contamination was largely restricted to the northern region of the Persian Gulf, particularly in Kuwait and Saudi Arabia. Increased concentrations of oil related heavy metals were found in surface soils downwind from the oil fires. Lead isotope ratios in Kuwaiti crude and soils proved to be useful tracers of the relative degree of contamination arising from the smoke fallout. Where fire fallout was heaviest, a survey found the sea surface micro-layer to be highly enriched in petroleum hydrocarbons containing concentrations 1-2 orders of magnitude higher than those measured in the underlying waters. In areas south of Bahrain, contaminant levels were similar to or lower than concentrations reported in earlier years.

Pesticides in the marine environment

Research on nuclear and non-nuclear techniques for assessing the impact of pesticide residues on the marine environment involved the development of new techniques for measuring second generation pesticides (e.g. organophosphorus

Pesticides in the marine environment (cont.)

compounds) and assessment of their environmental transfer and fate in the tropical marine environment using radiolabelled compounds. Much of this latter work was conducted at the Mazatlan marine station of the National Autonomous University of Mexico in a co-operative project sponsored by the CEC. A series of laboratory radiotracer 'microcosm' experiments were designed to follow the accumulation of ^{14}C labelled compounds such as chlorpyrifos, DDT and parathion by selected benthic organisms. In Mexico, similar experiments were scaled up to large volume, outdoor tanks or 'mesocosms' containing local lagoon fauna. Such radiotracer studies performed under conditions comparable to those in typical, tropical coastal lagoons have provided fresh insights into the cycling and food chain transfer of pesticides under natural conditions.

Additionally, a network of related pesticide research projects was set up in the Wider Caribbean region as part of a contribution to CEPPOL. A training course was also organized in Costa Rica for specialists from six Caribbean countries.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Use of nuclear and nuclear related techniques in the study of environmental pollution associated with solid wastes	1992	22
1988	Applications of stable tracers in human nutrition research	1992	15
1988	Rapid instrumental and separation methods for monitoring radionuclides in food and environmental samples	1992	12
1990	Assessment of environmental exposure to mercury in selected human populations as studied by nuclear and other techniques	1994	10
1990	Isotope aided studies of the bioavailability of iron and zinc from human diets	1994	11
1991	Applied research on air pollution using nuclear related analytical techniques	1996	2

Training courses and seminars held

Course name	Location	No. of participants	Duration
Application of nuclear analytical techniques to air pollution	USA	20	5 weeks
Sampling, sample preparation and evaluation for multielement and radionuclide analysis by nuclear and instrumental methods	India	15	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-616	Guidelines for leaching studies on coal fly ash and other solid wastes with special reference to the use of radioanalytical techniques

Industry and earth sciences

Industrial applications

General

Activities have continued to focus on the assessment of the main areas of industrial applications such as radiation processing, radiotracer technology, nucleonic control systems, on-stream analysers and non-destructive testing. Manpower development, dissemination of information and technology transfer were of principal importance.

Radiation processing

A CRP on radiation processing of flue gases was continued, with significant progress being noted in the development of technology. A large scale demonstration facility has been inaugurated in Poland. Plans to build two industrial scale demonstration facilities in Japan have been reported.

Technology transfer in industrial radiation sterilization has been carried out through the organization of regional training courses and workshops, with the main emphasis on new trends and developments in regulations concerned with industrial sterilization. The Agency has established liaison with ISO, which is actively working on the development of new standards. It is through the Agency that most developing countries (Asia and the Pacific and the Middle East and Europe) have had access to the information on these new standards.

Radiotracer applications

With the co-operation of consultants, work has started on the preparation of a technical report on nuclear geophysics in modern society. The report is intended to highlight many applications of nuclear geophysics in the prospection and exploitation of oil, gas, water, coal, and uranium and other minerals.

Nuclear techniques in the processing, modification and characterization of new materials

To assess the possibilities of introducing modern nuclear techniques for material development into developing countries, a consultants meeting on nuclear techniques in the development of advanced ceramic technologies was held at the Agency Headquarters in October. The meeting specified areas in material technology for which nuclear methods can be successfully applied using low and medium neutron flux reactors and indicated techniques that do not demand high cost equipment. These areas include:

- Investigation of ageing processes connected with structural changes, crystalization processes in glass ceramics and the determination of hydrogen content in sensitive chemical systems using neutron small angle scattering and absorption techniques.
- Modification of high temperature superconductors by neutron or heavy ion irradiation.

Non-destructive testing

Non-destructive testing methods and techniques are widely used in Member States for such purposes as controlling the quality of industrial products, providing quality assurance for conventional and nuclear installations and preventing dangerous accidents during the operation of transport systems. To advise the Agency on expected new developments in this field, a consultants meeting on advanced non-destructive testing techniques and applications was held at the Harwell Laboratory in the United Kingdom. The participants prepared the draft of an IAEA-TECDOC.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Radiation processing of combustion flue gases	1993	9
1988	Radiation processing technology applications in bioengineering	1992	9
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1992	6
1989	Nuclear techniques in the exploration and exploitation of coal: on-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke	1992	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of nuclear techniques for environmental preservation in resource extraction and processing	3	11

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on tracer applications in industry	Indonesia	13	2 weeks
Regional course on magnetic particle and liquid penetrant testing, level 3	Indonesia	18	19 days
Regional course on model qualifying examination in non-destructive testing radiography, level 3	Malaysia	16	5 days
Regional course on non-destructive testing radiography, level 3	Algeria	16	21 days
Fifth meeting of national co-ordinators for the radiation technology subproject	Japan	15	3 days
Expert group meeting on radiation vulcanization of natural rubber latex	Indonesia	7	3 days
Regional workshop on regulations in industrial sterilization	Thailand	14	1 week
Radiation curing	Australia	8	2 weeks
Radiation chemistry	Japan	10	2 weeks
Radiation vulcanization of natural rubber latex	Indonesia	12	2 weeks
Electron beam irradiation technology	China	10	2 weeks
Safe operation of industrial radiation facilities	Japan	10	1 week
Regional workshop on radiation sterilization of pharmaceuticals and drugs	India	13	1 week
National course on radiation chemistry and its applications	Indonesia	20	1 week
National course on radiation sterilization	Indonesia	35	2 weeks
National workshop on safe operation of industrial radiation facilities	China	100	1 week
National course on radiation sterilization	China	25	1 week
Workshop on regulations in industrial sterilization	Hungary	12	1 week
Workshop on problems in the transfer of radiation technology	Headquarters	20	1 week

Publications

Series and No.	Title
Proceedings Series	Nuclear techniques in the exploration and exploitation of energy and mineral resources
IAEA-TECDOC-628	Training guidelines in non-destructive testing techniques — 1991 edition

Development of water resources

Symposium

A symposium on the use of isotope techniques in water resources development was held in March. It was attended by 197 participants representing 51 countries and 2 international organizations. Nearly forty papers and over forty-five posters were presented.

The main theme of the symposium was the use of isotope techniques in solving practical problems of water resources assessment and development, especially with respect to groundwater protection, and in studying environmental problems related to water, including palaeohydrological and palaeoclimatological problems. A substantial part of the oral presentations was concerned with the present status and trends in groundwater dating and with methodological aspects.

The presentations showed that there is an increasing demand for the utilization of isotope methods, especially in water resources assessment in developing countries. Isotope methods have been recognized as being indispensable for solving problems such as characterization of palaeowater resources, evaluation of recharge and evaporative discharge under arid and semi-arid conditions, reconstruction of past climates, study of interrelationships between surface and groundwater, dating of groundwater, identification of pollution sources, and validation of contaminant transport models. The presentations on field studies which were carried out in numerous Member States demonstrated that isotope techniques, in combination with other hydrogeological and geochemical methods, have a potential in providing hydrological information such as indication and evaluation of origin, replenishment and dynamics of groundwater. Among new isotope techniques, the applicability of ^{36}Cl for studying very old groundwater, which is, for example, an important target in connection with the assessment of sites for nuclear waste disposal, was given special attention.

Mathematical models

The first co-ordination meeting of the CRP on mathematical models for the quantitative evaluation of isotope data in hydrology showed that progress had been made in developing formulations for isotope and tracer transport simulation in porous and fractured media, and the verification of these models in actual field applications.

Groundwater studies in arid and semi-arid zones

The groundwater resources of several arid and semi-arid zones have been studied, with the aim of assessing recharge origin and groundwater dynamics. The countries where investigations have been performed are: Cameroon, Chile (Rio San José basin, northern Chile), Egypt (Aswan High Dam region), Jordan, Mexico (Comarca Lagunera, Saltillo-Monterrey basin), Mongolia (Gobi Desert), Morocco (Errachidia, Kheng-el-Amman), Niger (Bilma, Ténéré Desert), Peru (Lima aquifer, Sechura desert, Tumbes-Zarumilla basin), Senegal, Sudan, the Syrian Arab Republic, the United Arab Emirates and Yemen. Apart from the usual occurrence of fossil groundwater — groundwater which has been recharged during humid climatic conditions — the isotopic studies have permitted a determination of evaporative losses (Niger), the identification of recharge from surface waters (Chile, Egypt, Peru, Sudan), and interconnections between aquifers (Morocco). In the Aswan High Dam region, the area of infiltration of the lake water has been defined.

Groundwater studies in arid and semi-arid zones (cont.)

A comprehensive study of the Figeh limestone aquifer — which is exploited for the water supply of Damascus — has allowed the identification of the replenishment area and an evaluation of the groundwater stored.

Groundwater investigations in tropical humid regions

In Viet Nam, the study of the aquifer system in the Mekong Delta using artificial tracers was completed. Studies have progressed in Bolivia (Cochabamba aquifer), Brazil (Meseta, Ceara; Bauru aquifer, São Paulo), Costa Rica (Río Tempisque valley), Colombia (Sabana de Bogotá aquifer system), Cuba (Jaruco-Aguacate karst aquifer, exploited to supply Havana), Ecuador (recharge origin in the Río Guayas valley), Guatemala (identification of Lake Atitlan losses to groundwater), Haiti (karst aquifer resources), Mauritius, Nicaragua (groundwater transit time in the Managua aquifer) and Zimbabwe. Most of the Latin American studies were performed within the framework of project ARCAL XIII and financially supported by Germany.

In the central Amazon, infiltration experiments with isotopic tracers were completed. They have shown a difference in water balance between native rain forest and deforested areas. A special report summarizing isotope aided studies of the Brazilian Amazon was prepared for publication.

Groundwater contamination and salinization studies

Groundwater contamination by surface water has been assessed and the origin and role of deep groundwater in the Lake Valencia basin (Venezuela) investigated. Studies began to assess the origin of salinization in the aquifer system of La Plata (Argentina) and Saltillo-Monterrey (Mexico).

Geothermal studies

Geothermal investigations are among those which benefit most from the application of isotope techniques. Radioactive isotopes have been used to identify the flow direction of reinjected geothermal fluid in Costa Rica and El Salvador. In other countries (Greece, Guatemala, Indonesia, Mexico, Nicaragua, the Philippines, Viet Nam) isotope techniques have been applied with Agency assistance for exploration purposes to assess the potential of geothermal areas and in particular to evaluate the temperature of the geothermal fluid at depth and establish its origin.

The first Research Co-ordination meeting of the CRP for Africa, Asia and the Middle East on the application of isotope and geochemical techniques in geothermal exploration, held in Beijing, China, reviewed the results recently obtained. Some important objectives have already been achieved, such as the identification of recharge sources, the evaluation of the temperature of the geothermal reservoir, and the collection of evidence for the occurrence of 'andesitic' water in geothermal discharges.

Studies in Italian geothermal fields have shown that radium isotopes can be used to evaluate fluid residence time in geothermal reservoirs.

Surface water and sedimentology

Dam leakages at the reservoirs of Agoyan (Ecuador) and Kouris (Cyprus) have been investigated by means of both artificial and environmental isotope tracers. Investigations have started on surface water pollution by industrial and domestic releases at Lake Valencia (Venezuela), Lake San Pablo (Ecuador) and the Río de La Plata estuary (Argentina); these investigations are financially supported by Germany.

Surface water and sedimentology (cont.)

A regional training course on the use of tracers in pollutant dispersion studies in surface waters was held in Buenos Aires in April. As part of the experimental programme, a large scale tracing experiment was carried out in the estuary of the La Plata River, using tritiated water to identify the areas affected by domestic water discharges.

Sedimentation studies were carried out in several countries. In Bangladesh, China and Malaysia, sea bottom sediment transport in connection with dredging practices was investigated by means of experiments with ^{46}Sc labelled glasses. In Cuba, Ecuador, Mali and Venezuela, sediment samples were collected from lakes and reservoirs to obtain information on sediment origin.

Precipitation and atmospheric studies

The determination of the isotopic composition of precipitation samples from the IAEA-WMO global network continued. The statistical elaboration of the existing database was completed and the database is ready for publication.

The determination of ^{85}Kr concentration in air continued, in collaboration with the Institut für Atmosphärische Radioaktivität, Freiburg, Germany.

A new CRP was launched, dealing with the isotope variations of carbon dioxide and other trace gases in the atmosphere. The programme is devoted essentially to the study of the origin, atmospheric cycle and sinks of CO_2, CH_4 and CO, the first two of which are important for the greenhouse effect.

Earthquake and volcanic eruption prediction

An Advisory Group meeting reviewed the technique of using isotopic and geochemical precursors of earthquakes and volcanic eruptions. Although the processes by which the precursor behaviour is governed are not fully understood and more research is needed, it appears that variations in the isotope ratios ^{3}He/^{4}He and ^{40}Ar/^{36}Ar, and variations in helium, argon, ^{222}Rn and hydrogen concentrations are the most promising precursors.

Isotopic standards and intercalibration

The ^{14}C intercomparison exercise organized for radiocarbon laboratories has been completed. Six intercomparison materials were distributed to 137 laboratories, 67 of which submitted their results to the Agency. These were evaluated by a consultants meeting and the conclusions presented at the 14th International Radiocarbon Conference in Tucson, USA. The intercomparison materials are now distributed on request for routine calibration of ^{14}C measurements, as part of the AQCS programme.

The Isotope Hydrology Laboratory continued to distribute stable isotope standards and intercomparison samples for the calibration of mass spectrometric measurements.

Assistance to Member State laboratories

Assistance to initiate and improve routine isotopic measurements was given to laboratories in Colombia, Indonesia, Jordan, Mexico, Sudan and Uruguay.

Co-operation with other United Nations organizations

Co-operation continued with all United Nations organizations working in the field of water resources, and especially with WMO (network for precipitation sampling) and UNESCO (symposium on water resources development).

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Nuclear techniques in the study of pollutant transport in the environment: interaction of solutes with geological media (methodological aspects)	1992	13
1990	Isotopes and geochemistry in geothermal exploration in Africa, Asia and the Pacific and the Middle East	1993	11
1990	Mathematical models for quantitative evaluation of isotope data in hydrology	1993	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Isotope variations of carbon dioxide and other trace gases in the atmosphere	3	12

Training courses and seminars held

Course name	Location	No. of participants	Duration
Use of tracers to study contaminant dispersion in surface water	Argentina	17	4 weeks

Publications

Series and No.	Title
IAEA-TECDOC-601	Use of artificial tracers in hydrology

Physical and chemical sciences

Nuclear and atomic data for applications

Data centre networks and services

The Agency continued to co-ordinate worldwide networks of nuclear and atomic data centres in order to ensure that data measured and evaluated in one country are made available quickly and efficiently to scientists and engineers in all Member States. There are three main data centre networks:

— for nuclear reaction data
— for nuclear structure and decay data
— for atomic and molecular data.

The Agency convenes annual co-ordination meetings of these networks which produce internationally available databases (CINDA, EXFOR, ENDF, ENSDF, ALADDIN, WRENDA, etc.). Copies of these databases are available on magnetic tapes or diskettes from the Agency. The available databases are advertised to data users by means of an Index of Data Libraries (document IAEA-NDS-7) and by the Nuclear Data Newsletter, of which more than 3000 copies are distributed in Member States.

During 1991 the Agency fulfilled more than 640 requests from 64 Member States for experimental and evaluated data, related data processing computer codes and nuclear data publications. Also during this year, the Agency acquired a VAX 4000 computer and related items of network communication equipment. Upon completion of the current development and testing stage, this VAX facility will provide data users with on-line access to the Agency's nuclear and atomic numerical databases.

New nuclear data libraries

Following a recommendation from a recently completed CRP on methods of calculation of neutron nuclear data for structural materials, a consultants meeting was convened to plan the development of a Reference Nuclear Parameter Library (RNPL) and to collect the first contributions to this database containing numerical input parameters to nuclear model computer programs.

The Agency continued to develop and provide to fusion design groups (including ITER) a comprehensive Fusion Evaluated Nuclear Data Library (FENDL). An Advisory Group meeting was convened to review progress on the database, which serves as a source of validated nuclear data for neutron and gamma ray transport calculations, as well as the prediction of important nuclear effects such as neutron activation, tritium breeding and material damage.

The Chinese Nuclear Data Centre, supported under a technical co-operation project, made available for distribution the second version of the Chinese Evaluated Nuclear Data Library (CENDL-2), which supplements other national and regional libraries such as BROND from the USSR, ENDF/B-6 from the USA, JEF-1 from the OECD/NEA and JENDL-3 from Japan.

A photonuclear data library was produced and made available for distribution by a co-operative effort of the USSR Photonuclear Data Centre in Moscow and the US National Nuclear Data Center in Brookhaven.

New nuclear data libraries (cont.)

As the result of a CRP, a PC database was produced containing X ray and gamma ray standards for detector calibration. This will contribute to the standardization of nuclear measurements in Member States.

Several special purpose nuclear data libraries were created and made available for distribution for applications in such areas as geophysics, quantitative activation analysis, analysis of fission product yields in fission reactors and activation of materials in fusion reactors.

The Agency has continued to develop and/or make available software for nuclear data processing. Important examples include the PC based ANDEX program for preparing files of experimental data in the international EXFOR format and utility codes on mainframe and PC for evaluated data in the international ENDF format.

New atomic and molecular (A+M) recommended databases

In collaboration with the atomic and molecular data centres at the Oak Ridge National Laboratory and at the National Institute for Fusion Science (Nagoya, Japan), a recommended database was established for state selective electron capture in collisions of fully stripped carbon and oxygen ions with hydrogen atoms.

Two consultants meetings were held to initiate the establishment of recommended atomic databases for He beam fusion alpha particle diagnostics and for Be and B fusion plasma impurities. Most of the recommended data have already been stored in the Agency's ALADDIN database in parametrized form.

Recommended plasma–material interaction (PMI) databases

A recommended database for light ion (H, D, T, He) reflection from all fusion relevant first wall reactor materials was established and stored in the ALADDIN PMI database. This database also includes self-ion reflection coefficients. A similar recommended database on physical sputtering of fusion relevant materials by light ion and self-ion bombardments has also been established.

A database on the thermomechanical properties of carbon based fusion reactor plasma facing materials was initiated as the result of a point evaluation effort by experts from several fusion and material science laboratories.

Currently available information on all important particle–surface interaction processes (ion backscattering, physical and chemical erosion, trapping/detrapping) and plasma–wall interaction phenomena was collected, critically evaluated and published as a data compendium.

Translations

The Agency continued to translate selected USSR nuclear data reports. Of particular interest to the nuclear data community were two data handbooks, one on charged particle nuclear data for thermonuclear fusion, INDC(CCP)-326, the other on photoneutron and photofission nuclear data, INDC(CCP)-337.

Technology transfer

Considerable support (expert assistance and computer equipment) was given to the development of national nuclear data centres in China, Indonesia and Algeria and a computational nuclear physics laboratory in Myanmar.

Nuclear data needed for neutron therapy

A CRP was completed in which participants assessed the status of nuclear data needed for neutron cancer therapy, including such applications as the selection of source reactions for neutron production, the design of collimators and shields, calculations of absorbed dose including heterogeneity corrections, microdosimetry and corrections for the influence of radiation quality on the production of biological effects. The final report, including the databases and documentation for the software developed by the participants, will be submitted for publication as an IAEA-TECDOC.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Measurements and analysis of double differential neutron emission cross-sections	1992	7
1989	Atomic and molecular data for fusion edge plasmas	1993	12
1989	Atomic and molecular data for radiotherapy	1993	14
1989	Activation cross-sections for the generation of long lived radionuclides	1994	8
1991	Plasma interaction induced erosion of fusion reactor materials	1994	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Compilation and evaluation of fission product yield nuclear data	3	7
Atomic data for medium and high Z impurities in fusion plasmas	3	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Computer based nuclear data processing for reactor physics	Headquaters	6	4 months

Publications

Series and No.	Title
Annual publication	CINDA 91
Supplement to *Nuclear Fusion*	Atomic and plasma–material interaction data for fusion, Vol. 1
Newsletter	Nuclear data newsletter, No. 15
INDC(NDS)-222/G + P	Progress in fission product nuclear data, No. 13
INDC(NDS)-244/M9	Sixth meeting of the IFRC subcommittee on atomic and molecular data for fusion
INDC(NDS)-245/L	Intermediate energy nuclear data for applications
INDC(NDS)-246/MO	Evaluation of thermomechanical properties data of carbon based plasma facing materials
INDC(NDS)-247/L	Methods for the calculation of neutron nuclear data for structural materials of fast and fusion reactors
INDC(NDS)-249	Particle reflection from surfaces: a recommended database
INDC(NDS)-250/GE	Co-ordination of the international network of nuclear structure and decay data evaluation
INDC(NDS)-251/L	Nuclear data for neutron emission in the fission process

Nuclear instrumentation

General

The activities related to nuclear instrumentation focus on:

- improving the maintenance and repair services for nuclear instruments in developing Member States
- development of specific software for nuclear applications
- design and construction of specific instruments as requested by Member States
- training.

The development of computer software for nuclear applications has continued, with improvements made in the programs for gamma and X ray analysis. Two publications in the Computer Manual Series (Nos 2 and 3) have been produced, describing the Agency's software packages GANAAS (for gamma spectrum analysis and neutron activation analysis), and SPEDAC (for transfer and reformatting of spectra).

Training

Training activities included two major interregional training courses, several regional courses in Latin America and Asia, and a number of national training courses. One of the important by-products of these training activities are comprehensive laboratory manuals that are being prepared for publication in the IAEA-TECDOC series. The Agency's Laboratory at Seibersdorf has continued its programme on group training in nuclear electronics and in X ray analysis.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Evaluation of multichannel analyser cards	Thailand	8	3 weeks
Evaluation of gamma spectrum analysis software	Costa Rica	13	3 weeks
Portable spectroscopy systems	Chile	9	3 weeks
Design and construction of MCA cards	Mexico	12	3 weeks
Redesign of QUAD system	Uruguay	18	3 months
Interregional course on nuclear electronics	Mexico	18	3 months
Interregional course on interfacing in nuclear experiments	Madagascar	25	2 months
Regional course on nuclear instrumentation (RCA)	Singapore	11	3 weeks
Regional course on repair and maintenance of multichannel analyser cards (ARCAL)	Brazil	20	4 weeks
Regional course on nuclear medical equipment maintenance (ARCAL)	Colombia	20	4 weeks

Publications

Series and No.	Title
Computer Manual Series, No. 2	Spectrum transfer and reformatting (SPEDAC)
Computer Manual Series, No. 3	Gamma spectrum analysis, activity calculations and neutron activation analysis (GANAAS)
IAEA-TECDOC-598	Regional co-operation on nuclear instrument maintenance
IAEA-TECDOC-619	X ray and gamma ray standards for detector calibration

Theoretical physics

Fields of research and training

The main fields of research and training for research at the International Centre for Theoretical Physics in 1991 were: fundamental physics (high energy, astrophysics, cosmology and particle physics); condensed matter physics (condensed matter physics and related atomic and molecular physics, materials science and engineering, computational condensed matter, surfaces and interfaces, liquids and statistical mechanics); mathematics (applicable mathematics, mathematics in development, differential geometry, differential equations, analysis and mathematical physics); physics and energy (plasma physics and nuclear physics); physics and the environment (geophysics, oceanography, seismology, climatology and meteorology, physics of the atmosphere, troposphere and magnetosphere and remote sensing); applied physics and high technology (physics in industry, microprocessors, communications, instrumentation, synchrotron radiation, VLSI design, optical fibres, lasers and computational physics).

Some 4000 scientists took part in the activities of the Centre and in the programme for training at Italian laboratories, staying for a total of over 4000 person-months. Out of this total, 52% were from developing countries, accounting for 75% of the total person-months. Associate Members from developing countries numbered 457, and there were 420 federated institutes in developing countries.

Funding

The agreement under which the Italian Government made its financial contribution to the Centre expired on 31 December 1990 and has not yet been renewed by the Italian Parliament. However, the implementation of the programme, with some curtailments, became feasible through loans advanced by UNIDO ($6 million and L. 2 billion in five different periods) as well as an advance payment of L. 9 billion given by the Italian Government, out of which a payment of L. 3 billion was approved at the end of November 1991. The contributions of the Agency and UNESCO amounted to $1 320 000 and $288 200, respectively.

The Centre also acknowledges with gratitude contributions from SAREC (Sweden), $322 689; UNIDO, $620 000; Japan, $39 120; Switzerland, $37 179; Brazil, $36 000; France (CNR), $16 528; the Islamic Republic of Iran (Ministry for Culture and Higher Education), $99 961 (Atomic Energy Organization), $25 000; the Italian National Institute for Nuclear Physics, $132 268; the United Kingdom (the Royal Society), $34 459; and the United Nations University, $10 000.

Fundamental physics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in fundamental physics and astrophysics	206	98	1 year
Diploma course in high energy physics	18	15	3 months
Spring school and workshop on string theory and quantum gravity	141	37	2 weeks
Trieste conference on quantum field theory and condensed matter physics	67	15	1 week
Second school on non-accelerator particle astrophysics	75	32	2 weeks
Summer school in high energy physics and cosmology	255	171	3 weeks
Trieste conference on recent developments in the phenomenology of particle physics	93	28	1 week

Condensed matter, atomic and molecular physics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in condensed matter physics	96	70	1 year
Diploma course on condensed matter physics	21	15	
Fifth international workshop on computational condensed matter physics	135	23	1 week
Experimental workshop on high temperature superconductors and related materials (basic activities)	85	66	3 weeks
Winter college on ultrafast phenomena	84	58	3 weeks
Spring college on nucleation, growth and segregation in materials science and engineering	129	102	4 weeks
Working party on initiation and growth of cracks in materials	66	50	2 weeks
Working party on simulation of materials degradation	31	23	3 weeks
Miniworkshop on non-linearity: fractals, pattern formation	66	47	3 weeks
Workshop on condensed matter physics	228	167	3 months
International conference on complex systems: fractals, spin glasses and neural networks	173	52	1 week
Miniworkshop on strongly correlated electron systems	66	31	4 weeks
Course on path integration	88	46	1 week
Working party on surface phase transitions	43	8	2 weeks
School on materials for electronics: growth, properties and applications	103	52	3 weeks

Mathematics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in mathematics	148	112	1 year
Workshop on mathematical physics and geometry	101	73	2 weeks
College on singularity theory	210	93	3 weeks
School on dynamical systems	149	91	3 weeks
Workshop on stochastic and deterministic models	32	8	1 week

Physics and energy

Course name	Total No. of participants	Participants from developing countries	Duration
Research in plasma physics	14	14	1 year
Fifth workshop on perspectives in nuclear physics at intermediate energies	110	27	1 week
Spring college on plasma physics	130	86	3 weeks

Physics and the environment

Course name	Total No. of participants	Participants from developing countries	Duration
ICS-ICTP-WMO international technical conference on long range weather forecasting research	69	31	1 week
Course on oceanography of semi-enclosed seas	89	54	3 weeks
Course on ocean–atmosphere interactions in the tropics	39	21	3 weeks
Conference on major problems of the atmospheric system and the developing countries	62	40	1 week
Second international workshop on radon monitoring in radioprotection, environmental and/or earth sciences	100	41	2 weeks
Workshop on non-linear dynamics and earthquake prediction	59	31	3 weeks

Applied physics and high technology

Course name	Total No. of participants	Participants from developing countries	Duration
Microprocessors laboratory	7	5	1 year
High temperature superconductivity experimental laboratory	17	12	1 year
Second college on theoretical and experimental radiopropagation physics	68	58	3 weeks
Winter college on multilevel techniques in computational physics (physics and computations with multiple scales of lengths)	76	42	2 weeks
Second training college on physics and technology of lasers and optical fibres	90	53	3 weeks
Second ICTP–INFN course on basic VLSI design techniques	44	39	4 weeks
Fourth ICFA school on instrumentation in elementary particle physics	62	24	2 weeks
School on use of synchrotron radiation in science and technology	74	46	4 weeks

Adriatico Research Conferences

In 1991, the Adriatico Research Conferences series included short meetings on: structural and phase stability of alloys, the physics of inhomogeneous materials, open problems in strongly interacting electron systems and path integration and its applications. Seventy-four scientists from developing countries, out of a total of 211, took part.

Training at Italian laboratories

One hundred and seven scientists from developing countries carried out research at Italian academic and industrial laboratories under a programme which started in 1982 with the financial support of the Italian Direzione Generale per la Cooperazione allo Sviluppo (Ministry for Foreign Affairs, Rome, Italy).

External activities

In the fields of physics and pure and applied mathematics, the Centre sponsored 51 activities, courses, workshops and symposia in 26 countries. Ten Affiliated Centres were established in ten countries and three networks were created involving nine countries. These programmes were financed by the Direzione Generale per la Cooperazione allo Sviluppo of the Italian Ministry of Foreign Affairs.

Co-sponsored activities

The Centre co-sponsored four activities, courses workshops and schools with the participation of 135 scientists, out of which 23 were from developing countries.

Meetings hosted by the Centre

The Centre hosted 11 meetings; two of them were organized by the International Centre for Science and High Technology, while other major organizing institutions were the International Centre for Genetic Engineering and Biotechnology, the International Bathymetric Chart of the Mediterranean, the Third World Academy of Sciences, the International Institute for Pure and Applied Chemistry and the International School for Advanced Studies.

Other conferences

A two-day round table on the scientific brain drain in the Third World and in central and western Europe was held in March in Trieste. The recent emigration from Mediterranean and developing countries as well as from central and eastern Europe was discussed. There were 100 participants, out of which 35 were from developing countries.

An eight-day symposium was held in March in Edinburgh in co-operation with the International Centre for Mathematical Sciences and the Edinburgh Mathematical Society. The main subjects were geometry and mathematical physics. One hundred scientists attended, out of which 17 were from developing countries.

Books and equipment donation programme

During 1991, the Centre was able to distribute 20 655 journals, 5150 proceedings, 3175 books and 2843 miscellaneous publications to some 1500 institutions in 100 developing countries. In addition to the donations directly distributed by the Centre, a large number of donations of complete sets of back issues of journals were shipped directly by the donors to institutions in developing countries.

Awards

The 1991 Dirac Medals of the ICTP were awarded to Jeffrey Goldstone from the Massachusetts Institute of Technology, Cambridge, USA, for fundamental clarification of the phenomenon of spontaneous symmetry violation in relativistic quantum field theory, and to Stanley Mandelstam from the University of California, Berkeley, USA, for his work on the representation of the analytic properties of scattering amplitudes and path integral quantization methods in string theory.

Special Dirac medals were given to Margit Dirac (United Kingdom) and Claudio Villi (Italy).

The 1991 ICTP Prize in honour of Ettore Majorana was awarded to Hong Van Le, from the Institute of Mathematics, Hanoi, Viet Nam, for her profound work on calibrations applied to the theory of minimal surfaces and Lagrangian submanifolds.

Preprints and internal reports

In 1991, 403 preprints and internal reports were issued.

Publications

Series and No.	Title
IAEA-TECDOC-625	International Centre for Theoretical Physics: scientific activities in 1990

Utilization of research reactors and particle accelerators

Research reactor database

Work on updating the research reactor database continued. A programme to adapt this database to PC rather than mainframe computer use was started.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Analysis of research reactor cores for use of LEU fuels	1992	6
1990	Application of personal computers to enhance operation and management of research reactors	1993	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Workshop on research reactors in Latin America	Chile	60	1 week
Regional course on research reactor control and calculation (RCA)	Indonesia	13	3 weeks
Regional course on the use of personal computers in research reactor operation and management (RCA)	Indonesia	14	3 weeks

Publications

Series and No.	Title
Reference Data Series No. 3	Nuclear research reactors in the world, May 1991 edition

Chemistry

Laboratory manual

A laboratory manual on the preparation of ^{99}Tc^{m} radiopharmaceutical kits has been prepared for publication. The manual is intended to help professionals from developing countries in their efforts to start indigenous production programmes.

Labelling on monoclonal antibodies

At the first co-ordination meeting held in Malaysia on the CRP on labelling, quality control and clinical evaluation of monoclonal antibodies for scintigraphy, recent advances in the field were reviewed. The advantages and drawbacks of existing labelling and quality control procedures were assessed. Protocols for labelling and quality control were agreed upon for the next phase of the CRP. In addition to the anti-carcinoembryonic antigen monoclonal antibody, it was decided, for reasons of availability, to include as part of the programme a second antibody, the 170 monoclonal antibody, which is also a tumour seeking monoclonal antibody.

Therapeutic agents

The preparation and quality control aspects of radiopharmaceuticals as radionuclide carriers for therapeutic applications were reviewed with the help of consultants. It was concluded that thanks to the recent advances in radiopharmaceutical chemistry and the greater availability of radionuclides with appropriate characteristics, there are nowadays laboratory procedures for the safe preparation of these agents for an array of therapeutic radiopharmaceuticals. The transfer of this know-how to developing countries was also considered feasible. Recent clinical trials have shown that the procedures offer promising alternatives to other cancer therapy strategies, particularly for bone metastases and bone pain palliation.

Immobilized antibodies for RIA and IRMA

Recent developments and progress achieved under the auspices of the CRP on antibodies immobilized on magnetic particles for radioimmunoassay and immunoradiometric assays of hormones were reviewed during the first Research Co-ordination meeting held in London. Promising results were obtained for blood spot TSH assays, both for neonates and for adults. Work will continue to further develop the magnetic particle method for the preparation of kits and optimization of the assays.

^{99}Tc^{m} alternative generator technology

In the Research Co-ordination meeting held in Thailand within the framework of the CRP on alternative technologies for ^{99}Tc^{m} generators based on low temperature sublimation and gel elution, the current status of the research work was discussed. The results show the excellent potential of these technologies for practical use in nuclear medicine. Use of alternate technologies for ^{99}Tc^{m} generators using relatively low specific activity ^{99}Mo produced in research reactors would provide a less complex, less expensive and more practical route for indigenous production and use of ^{99}Tc^{m} in developing countries.

Laboratory activities

The Chemistry Unit of the Agency's Laboratory at Seibersdorf continued to provide support and assistance to laboratories in Member States involved in the analysis of nuclear, environmental and biological materials through the Analytical Quality Control Services (AQCS). This assistance includes the organization of intercomparison studies, distribution of reference materials, training and consulting with fellows and scientific visitors.

Laboratory activities
(cont.)

In 1991, 18 intercomparison runs with different materials, two of which were collected near the Chernobyl nuclear power station, were organized. About two thousand reference materials were distributed according to the requests of different laboratories. Two intercomparison runs (IAEA-363, uranium concentrate, and IAEA-364, uranium phosphate ore for trace elements) were completed and three analytical reference materials were certified by the Chemistry Unit.

The Unit also provided analytical support to three CRPs and various technical co-operation projects (about three thousand analyses) and the training of fellows and scientific visitors (a total of 38 person-months) in the use of analytical and nuclear techniques for the analysis of trace elements and radionuclides.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Nuclear analytical techniques for trace element analysis in agricultural products and food	1992	11
1989	Radiotracers in the development of new separation techniques for trace element analysis by nuclear methods, with special emphasis on environmental research	1992	14
1990	Labelling, quality control and clinical evaluation of monoclonal antibodies for scintigraphy	1993	13
1990	Evaluation of bulk reagents for production of $^{99}\text{Tc}^{m}$ radiopharmaceutical kits	1993	10
1991	Antibodies immobilized on magnetic particles for radioimmunoassay and immunoradiometric assay of hormones	1994	10
1991	Alternative technologies for $^{99}\text{Tc}^{m}$ generators based on low temperature sublimation and gel elution	1994	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Nuclear analytical techniques in atmospheric and water pollution studies	3	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Application of nuclear analytical techniques in mineral exploration and exploitation	Ghana	16	3 weeks
Nuclear analytical techniques in agroindustry and food	Brazil	16	4 weeks
Workshop on generator and cyclotron produced radiopharmaceuticals	Saudi Arabia	11	3 weeks

Radiation protection

Basic radiation safety policy

Basic criteria

The Basic Safety Standards (BSS) for Radiation Protection are being revised in the light of the 1990 recommendations of the ICRP (ICRP Publication 30). The major changes from the current (1982) edition of the BSS include reduced occupational dose limits, an extension of the radiation protection system to include 'potential' exposures (those that could result from events such as accidents, errors and equipment failure) and a more coherent treatment of the intervention required in order to avert exposures following accidents and in some situations involving natural sources of radiation. It is intended that the main part of the revised BSS consist of basic radiation protection requirements in the form of concise statements, with any necessary explanatory and other supporting material kept separate. The revision is being carried out by a joint secretariat representing the Agency, OECD/NEA, WHO, ILO, the Pan American Health Organization (PAHO) and FAO, with the participation of an ICRP liaison group so as to assure compatibility with the ICRP recommendations, and a CEC liaison group in order to ensure compatibility with the CEC's directives on radiation protection, which are also being revised in the light of the latest ICRP recommendations. The joint secretariat and liaison groups met in December to determine the additional drafting needed before submitting their draft to a Senior Experts Group for review in February 1992. The revised draft is then to be sent to Member States for comment.

Occupational radiation protection

Co-operation with international standards organizations

The ICRP issued a major publication containing new guidance related to radiation protection. The International Commission on Radiation Units and Measurements (ICRU) is nearing publication of its guidance on practical implementation of operational quantities for the external monitoring of personnel. The Agency continued three CRPs directly coupled to the work of these commissions in: (1) developing information necessary for the effective application of the new guidance, and (2) providing supplemental information for an additional publication under development.

Worker protection in the nuclear industry

As part of its programme to place more emphasis on radiation protection for the worker, the Agency extended its collaboration with the OECD/NEA in the development of a worldwide occupational exposure database for workers in the nuclear power industry. The Agency also responded to a request to the Director General from the Soviet General Confederation of Trade Unions by participating in the International Consultative Meeting of Trade Unions on Atomic Energy, held in Moscow in April. Participants included representatives from two international and six national trade unions.

Database development

The problem of efficiently providing timely information related to occupational radiation protection to Member States has grown rapidly. Following the recommendations of an Advisory Group convened at the end of 1990, a programme was initiated on database development to: (1) provide specialists in Member States with the information necessary for effective occupational protection, and (2) improve the Agency's ability to provide a timely assessment of the worldwide occupational protection situation. Specifically, effort was begun on the unilateral or collaborative development of databases on existing radiation protection databases, OECD/NEA-IAEA occupational exposure statistics, a medical registry of radiation accidents, and a registry of sealed sources and device controls.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Intercomparison for individual monitoring	1992	24
1988	Compilation of anatomical, physiological and metabolic characteristics for a reference Asian man	1993	11
1988	Dose per unit intake factors for members of the public	1993	11
1990	Use of natural materials for dose assessments	1993	8
1991	Radiological impact of hot beta particles from the Chernobyl fallout: risk assessment	1993	16

Publications

Series and No.	Title
Technical Reports Series No. 324	Safe handling of tritium: review of data and experience

Radiation protection of the public and the environment

International Chernobyl Project

The International Chernobyl Project, which was undertaken in 1990 in response to a request from the USSR, was completed in 1991 and its results presented to the scientific community, the public and the media. The Project, in which some 200 experts from 25 countries and 7 international organizations participated, was overseen by an International Advisory Committee, which approved the reports and the Project's conclusions and recommendations. The Project was co-ordinated by the Agency, which also served as its secretariat. The assessment was concerned specifically with persons residing in settlements in the contaminated areas since the time of the accident because many people had expressed uncertainty over the actual health and environmental situation.

The International Advisory Committee concluded that, although there were significant health disorders not related to radiation in the populations examined, none of these disorders could be attributed directly to radiation. It was noted, though, that the accident had, and continues to have, considerable psychological consequences.

The extensive medical data examined did not indicate a substantial increase in the incidence of leukaemia, cancer or hereditary effects. While the data did reveal that the incidence of cancer had been rising for the last decade, this increase started before the Chernobyl accident and has continued at the same rate since. The data did not show a marked increase in childhood leukaemia or thyroid tumours since the accident.

However, because of limitations in the investigative and statistical methods used in the Project, the possibility of some slight increase in the incidence of cancers cannot be altogether excluded. Nor can the development of an increased number of cancer cases after a longer latent period. Cancer, however, is a very common disease, which is responsible for more than 20% of all deaths, and it has many causes. Unless the number of radiation induced cancers is large, it may be difficult to be certain that there is any effect attributable to radiation. Only well organized statistical studies may in the long term be able to establish such an effect.

ATMES

The joint Agency, WHO and CEC Atmospheric Transport Model Evaluation Study (ATMES) was completed and its results presented and discussed at a workshop hosted by the Joint Research Centre, Ispra. Some 21 modellists participated in this study, which utilized the Chernobyl accident source term and the environmental measurements made by European countries following the accident. The data presented showed that while there were reasonably good results achieved with actual meteorological data, operation in a predictive mode was still lacking. The uncertainties in the source term and in the environmental data added to the model uncertainties and contributed to the overall inaccuracies in the predictions, especially for the longer term and for more distant regions.

Reduction of radiocaesium levels in milk and meat in contaminated land areas

As part of the International Chernobyl Project, collaborative work on the use and implementation of Prussian Blue (specifically ammonium hexacyanoferrate (II)) boli was established between the Ukrainian SSR (UkrSSR), Byelorussian SSR (BSSR), Russian Soviet Federated Socialist Republic (RSFSR), Norway, the Agency and FAO. These boli have been developed in Norway to reduce the radiocaesium content of reindeer meat contaminated by fallout from the

Reduction of radiocaesium levels in milk and meat in contaminated land areas (cont.)

Chernobyl accident. The main aim is to facilitate the use of the boli in reducing the radiocaesium content of milk and meat from cattle grazing contaminated pasture in these affected areas.

To this end, extensive field trials were carried out during the 1991 summe grazing season in these three republics, both on collective farms and on individual plots of land. The results were extremely promising, with a reduction factor for the caesium content in both milk and meat of between 2.5 and 4. Milk and meat were examined for changes in micro and macroelements, in the physicochemical characteristics, and in toxicology. As expected, none were found. The method seemed to be readily accepted by the farming community, particularly individual farmers, and it has been shown to be an extremely cost effective method for reducing contamination. Industrial facilities were established in the UkrSSR and BSSR for future production of the boli. The respective Ministries of Health are now performing their own experimental investigations in order to authorize the use of Prussian Blue for this purpose. The collaboration is expected to continue in 1992 to facilitate full implementation.

Protection of the public

With the new recommendations of the ICRP on radiation safety, the Agency has initiated work on several topics in support of the development of revised inter-agency Basic Safety Standards. In one of these topics, protection of the public following a nuclear accident, considerable progress has been made on harmonizing international intervention levels, and on defining and deriving numerical values for 'dose constraints' for protecting members of the public during routine operations.

International radon database

Over the next five years a large number of national radon programmes will be completed worldwide. In order to facilitate the use of these data by the scientific and regulatory community, a structured format for data input into an international radon database has been initiated with the assistance of the US Environmental Protection Agency.

Hot particles risk assessment

A new CRP was initiated on risk assessment of the radiological impact of hot beta particles from the Chernobyl fallout. The accident at the Chernobyl reactor in April 1986 released massive quantities of highly radioactive aerosols into the environment. It was already recognized at an early stage of the follow-up actions for accident management that in addition to homogeneously distributed fission product materials (volatiles and finer particles), the Chernobyl radioactive fallout contained a significant fraction of larger, discrete, high specific activity particulate fragments (around 1 mm or less in diameter) known as hot particles. This CRP was designed to provide much needed data on the radiobiological effects and health physics aspects of high specific activity hot beta particles potentially encountered by persons exposed to fallout from the Chernobyl reactor accident. These interdisciplinary data, generated by the CRP investigators in accordance with standardized protocols and parameters to permit intercomparison, should, when integrated, facilitate practical recommendations on risk estimation and radiological protection implementation. The first Research Co-ordination meeting took place in Kiev (Ukraine) in August 1991.

Chernobyl Centre for International Research (CHECIR)

Two project definition meetings were held in Zeleny Myss near Chernobyl. A research team from the Republic of Korea began studies on decontamination work and remained on-site for three months. Several groups of interested scientists from four Member States visited the region to get acquainted with the possibilities for research on-site within the exclusion zone. The CEC initiated some six major research projects for implementation within the framework of CHECIR.

The legal framework to permit extensive international research at Chernobyl is established. The actual level of interest shown in 1991 by foreign laboratories was less than the scope of the studies offered. The focus of current interest rests essentially with decontamination and radioecology.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1981	Use of chromosomal aberration analysis in radiation protection	1990	14
1988	Dose per unit intake factors for members of the public	1991	11
1990	Use of natural materials for solid state dosimetry in accident zones and the environment	1993	8
1990	Radiological impact of hot beta particles from the Chernobyl fallout: risk assessment	1993	16
1990	Radon in the human environment	1994	55

Training courses and seminars held

Course name	Location	No. of participants	Duration
Environmental monitoring related to the assessment of the safety of nuclear facilities	China	20	2 weeks

Publications

Series and No.	Title
Special publication	The International Chernobyl Project: technical report
Special publication	The International Chernobyl Project: an overview
Special publication	The International Chernobyl Project: surface contamination maps
Special publication	The International Chernobyl Project: proceedings of an international conference

Safe transport of radioactive materials

Transport regulations

The first meeting was held in Vienna of a Revision Panel established by the Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM) to deal with proposals for changes in the Transport Regulations by Member States and international organizations which will be incorporated in the 1996 comprehensively revised edition. The three areas identified as having the greatest impact on the Regulations are: the new ICRP recommendations on radiation protection; provisions for the air transport of large quantities of radioactive material; and the transport of uranium hexafluoride.

Air transport

An Advisory Group meeting was convened to finalize a document comprising new draft regulatory requirements for the transport of large quantities of radioactive material by air. Although further adjustments will be made before the next revision of the Regulations, it was agreed that the document should be published in the IAEA-TECDOC series. It is expected to serve as a basis for further consultations with Member States with a view to subsuming provisions for the air transport of large quantities of radioactive materials in the new, comprehensively revised edition of the Agency's Transport Regulations (Safety Series No. 6) in 1996.

Transport of UF_6

Broad consensus was reached on regulatory requirements for the transport of UF_6. The specific provisions have been published as an IAEA-TECDOC. Outstanding issues, particularly regarding the temperature modelling of packages designed for the transport of UF_6, need to be dealt with.

Database development

A first report of the REDTRAM database, consisting of abstracts of current research on the safe transport of radioactive materials, was published. It also contains the results of a recently concluded CRP on the radiation protection implications of transport accidents involving radioactive material.

Data collection was pursued for the EVTRAM (accidents and incidents), SHIPTRAM (shipments of radioactive material) and EXTRAM (exposures during transport) databases. The data are being submitted by Member States and a report on all of these databases is scheduled to be published as an IAEA-TECDOC in 1992.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Development of probabilistic safety assessment techniques related to the safe transport of radioactive material	1993	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Assessment of safety of UF_6 packages in fires	3	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the safe transport of radioactive material	United Kingdom	24	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-608	Interim guidance on the safe transport of uranium hexafluoride
IAEA-TECDOC-617	Directory of national competent authorities' approval certificates for package design, special form material and shipment of radioactive material — 1991 edition
IAEA-NCAL-22	National competent authorities responsible for approvals and authorizations in respect of the transport of radioactive material, list No. 22
IAEA-TSRA-1	Transport safety research abstracts, No. 1
IAEA-TCS-1	Safe transport of radioactive material. Second edition

Emergency planning and preparedness

Emergency Response System

As a result of a comprehensive exercise of the Agency's Emergency Response System (ERS) conducted in April 1990, several modifications were implemented, including changes to the organization and implementation procedures of the ERS and to the Agency's Emergency Response Unit. Retraining of the staff has been conducted and preparations for a second exercise of the ERS in early 1992 were undertaken.

Rapid post-accident data reporting

The Agency and the CEC have, in conjunction, developed software programs for the Member States which will assist them during an emergency in preparing and decoding messages containing detailed information and data about an accident.

Assistance to Member States

The Agency provided, through its technical co-operation and assistance programme, direct support to emergency planning and preparedness programmes in 11 Member States. This included the furnishing of expert services, and necessary equipment, plus the provision of fellowships and scientific visits for upgrading the capability of professional staff.

Observation of emergency exercises

Continuing an activity which was started some years ago, the Agency accepted invitations to attend, observe and evaluate emergency exercises in two Member States. Experience has shown that this approach brings to light, during a very short period, both the positive aspects of the country's preparedness for nuclear accidents and those aspects which need correction, amendments or improvements.

Training courses and seminars held

Course name	Location	No. of participants	Duration
African regional workshop on the development of national emergency plans	Headquarters	14	2 weeks
Interregional course on the planning and preparedness for and response to radiological emergencies	USA	29	4 weeks

Control and safe use of radiation sources

Involvement in radiological accidents

Three major accidents occurred in 1991. The first, during December 1990–January 1991 was in Spain, where 27 patients were overexposed inadvertently to a linear accelerator (13 patients died, the ultimate cause of death is still under discussion). The second accident took place in France, in August, resulting in three overexposed workers, one of them severely; the third accident occurred in the BSSR on 26 October, where one worker was highly exposed.

A Technical Committee meeting was held in order to review radiological accidents in industrial irradiation facilities, and for the first time complete information on earlier Italian and Norwegian accidents was given. In addition, the accidents in San Salvador and Israel were discussed.

Video film for operators of industrial irradiators

With the co-operation of the United Kingdom National Radiological Protection Board, the Health and Safety Executive and the UK Gamma Panel, a video film was developed for operators of industrial irradiators. The video is intended as a complement to workers' training and will be available early in 1992.

Safe use and regulation of radiation sources

A training manual on the safe use and regulation of radiation sources is being developed using material from three interregional training courses. The draft manual proved to be very useful during a regional training course which took place in Kuala Lumpur for the Asia and Pacific region.

Registry of radiation sources and devices

An international registry of radiation sources and devices was set up with the support of the US Nuclear Regulatory Commission in order to assist competent authorities in licensing procedures and to help them in the identification of lost or abandoned sources and devices. The registry includes more than 3000 sources and devices.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on safe use and regulation of radiation	Mexico	19	5 weeks
Regional course on safe use and regulation of radiation sources	Malaysia	21	5 weeks
Regional course on safe operation of industrial irradiators	Mexico	17	2 weeks
National workshop on safe operation of industrial gamma and electron beam facilities	China	100	1 week
Regional course on safe operation of industrial radiation processing facilities	Japan	12	1 week

Radiation safety services

RAPAT

Four Radiation Protection Advisory Team (RAPAT) missions were carried out in 1991, bringing the total number of Member States visited since 1984 to 56. The requests were received from Hong Kong (United Kingdom), Niger, Paraguay and Sierra Leone. The missions focused on reviewing immediate infrastructural needs and defining longer term strategies for technical assistance and co-operation in radiation protection.

More emphasis was given to the RAPAT follow-up and implementation programme. Group training activities were sponsored (involving the Democratic People's Republic of Korea, Mongolia, Viet Nam and Sri Lanka) and expert missions were requested (Chile and China) in response to recommendations made by RAPAT.

Personnel monitoring services provided by the Agency in 1991

Personnel dose evaluations (TLD)[a]	13 000
Fast neutron dosimeters	300
Extremity dosimeters	1 000
Area monitoring	600
Air monitoring (Safeguards Analytical Laboratory, Seibersdorf)	460
Whole body countings	950
Urine analyses (^{90}Sr, ^{239}Pu and ^{241}Pu)	850

[a] TLD: thermoluminescent dosimetry.

Personnel dosimetry and monitoring

The Agency's Health Physics Laboratory was supplied with the latest equipment which will improve both the capability and quality of its personnel dosimetry services. A new chemistry laboratory and gamma spectrometry facility — to be ready in early 1992 — will further improve these services.

UNSCR 687 action plan

Radiation protection support for United Nations Security Council Resolution 687 (UNSCR 687) was provided during eight special safeguards inspections to Iraq. The support included personnel dosimetry, radiological surveillance of inspected premises and radiological certification of consignments. Altogether, Agency health physicists and technicians spent 150 person-days on these assignments.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Radiation protection for new safeguards inspectors	Headquarters	17	3 days
Workshop on the development of a national infrastructure for radiation safety (RAPAT follow-up)	Democratic People's Republic of Korea	20	2 weeks
Workshop on the development of a national infrastructure for radiation safety (RAPAT follow-up)	Mongolia	23	2 weeks
National workshop on personnel dosimetry and instrument calibration (RAPAT follow-up)	Viet Nam	30	1 week
National workshop on radiation protection in medicine for specialists	Sri Lanka	20	1 week
National workshop on radiation protection in medicine for nurses	Sri Lanka	24	2 days
Regional co-ordination meeting on radiation protection projects	Islamic Republic of Iran	17	4 days
Two regional workshops (Africa) on trouble shooting and maintenance of TLD equipment	Headquarters	9 and 6	1 week each
Regional workshop (Africa) on emergency planning and preparedness and international co-operation during radiological emergencies	Headquarters	10	1 week
Regional workshop (Middle East) on advanced radiochemical techniques for the monitoring of food and environmental samples	Syrian Arab Republic	12	4 weeks
Regional course (RCA) on the basic techniques of radiation protection	Japan	12	2 weeks
Course (RCA) on safety aspects in the industrial application of radiation sources	India	14	2 weeks
Regional course (RCA) on environmental monitoring related to the assessment of the safety of nuclear facilities	China	12	2 weeks
Regional course on safe operation of industrial radiation facilities	Mexico	19	2 weeks
Regional course on thermoluminescence applied to dosimetry	Ecuador	20	2 weeks
Regional course on radiological emergencies	Peru	17	2 weeks
Regional course on safety and regulation of radiation sources	Mexico	19	5 weeks
Workshop on technical criteria for personnel dosimetry services	Chile	10	1 week
Workshop on disposal of medical and industrial radiation sources	Colombia	7	1 week

Safety of nuclear installations

Liability for nuclear damage

The Standing Committee on Liability for Nuclear Damage held two regular sessions and two intersessional meetings during which further progress was made in the consideration of various aspects of strengthening the existing international liability regime. In particular, preliminary agreement was reached on a number of specific draft texts to amend the Vienna Convention, embracing most of the issues where a need for improvement was recognized (e.g. extension of geographical scope, expansion of the concept of nuclear damage to cover damage caused by contamination of the environment and increase of the financial limits of operator's liability). While alternative approaches remained before the Committee on several fundamental questions, such as supplementary compensation, application of the Vienna Convention to military installations, and procedures for the settlement of claims, the number of options was reduced and this opened up prospects for reaching a convergence of views. On the issue of international State liability and its relationship to the civil liability regime under the revised Vienna Convention, the Committee moved from general discussion to consideration of specific alternative proposals. In the light of the present stage of deliberations, the revision conference for the Vienna Convention tentatively planned for 1991 has been postponed until the necessary preparatory work has been completed.

At its meeting in June, the Board of Governors considered the question of liability for nuclear damage. The General Conference, acting on the report by the Board, reiterated the priority it attached to the consideration of all aspects of the question of liability for damage arising from a nuclear accident, especially in the light of the requests from Parties to the Vienna Convention to convene a revision conference (GC(XXXV)/RES/553).

Physical protection of nuclear material

Since Article 16.1 of the Convention on the Physical Protection of Nuclear Material provides that a conference is to be convened five years after its entry into force "to review the implementation of the Convention and its adequacy as concerns the preamble, the whole of the operative part and the annexes in the light of the then prevailing situation", a Preparatory Committee for the Review Conference of the Convention met at Headquarters in October. Thirty Parties to the Convention were represented. The Committee, inter alia, agreed that: the Review Conference be held at Headquarters from 29 June to 3 July 1992; Parties to the Convention be invited to attend as participants; signatories to the Convention, Member States of the Agency and specified intergovernmental organizations be invited as observers. The Committee also agreed on proposed rules of procedure and a proposed provisional agenda.

International convention on nuclear safety

Pursuant to General Conference Resolution GC(XXXV)/RES/553, the Director General convened a group of 36 experts designated by Member States and relevant international organizations (CEC, ILO and OECD/NEA), as well as the chairmen of NUSSAG, INWAC and SAGSTRAM, to advise on the structure and content of an international nuclear safety convention. The experts expressed strong general support for an international instrument on nuclear safety. They reiterated the principle that nuclear safety was primarily a question of national responsibility. The instrument should, in principle, underline such a responsibility. The possible elements (preamble, objectives, scope, obligations and institutional mechanisms) for inclusion in a convention were elaborated. The expert group concluded that the proposals outlined formed an appropriate basis for preparatory work.

Basic nuclear safety principles and criteria

Safety standards and criteria

The Nuclear Safety Standards Advisory Group (NUSSAG) reviewed the revised texts of two Safety Guides in the design area of NUSS. The first guide, dealing with fire protection, was revised since its initial publication in 1979 to incorporate advances in the discipline and include information on the Chernobyl accident. The second guide, dealing with seismic design and qualification, was revised to include advances in the state of the art and more specific guidance than originally offered.

INSAG

The Agency's International Nuclear Safety Advisory Group (INSAG) completed its deliberations on a report entitled The Safety of Nuclear Power. The report covers important elements of the history of nuclear plant safety, current reactor safety principles, the safety of nuclear plants, the nuclear fuel cycle, features desired in future plants and the continued improvement of nuclear power plant safety. The report is to be published as Safety Series No. 75-INSAG-5.

Probabilistic safety assessment (PSA) was also considered by INSAG, which initiated the preparation of a report on the capabilities and limitations of PSA methodology, further development of the methodology and guidance for presentation and interpretation of PSA results.

Since the Post-Accident Review Meeting on the Chernobyl Accident and INSAG's summary report (Safety Series No. 75-INSAG-1), a considerable amount of additional information has been made available by experts throughout the world on the causes of the accident. INSAG reviewed these reports and decided to prepare an addendum to INSAG-1. The addendum will concentrate on the causes of the accident.

Regulatory practices on ageing nuclear power plants

A second round of peer discussions was initiated on the subject of the regulatory practices relating to the monitoring and assessment of ageing nuclear power plants. Two meetings were held, with four countries per meeting (Bulgaria, Canada, Czechoslovakia, Finland, Sweden, the UK and the USSR are participating to date) and three more meetings are to follow. Good practices discussed in the first round of meetings on regulatory inspection practices for nuclear power plants were incorporated into a draft Safety Practices document currently under review by the 13 countries that participated in those discussions.

Conference on the Safety of Nuclear Power

The conference on the Safety of Nuclear Power, organized by the Agency and held in Vienna in September, was attended by 350 experts from more than 40 countries and 10 international organizations. The objective of the conference was: to review, at the technical and policy making levels, the nuclear power safety issues on which international consensus would be desirable; to address the concerns on nuclear safety expressed by the United Nations World Commission on Environment and Development (Our Common Future); and to formulate recommendations for future actions by national and international authorities to advance nuclear safety to the highest level, including proposals for the Agency's future activities for consideration by the Board of Governors and the 1991 General Conference.

The discussions revolved around five issues on which background papers had been prepared and comments solicited prior to the conference. These issues were: the fundamental principles for the safe use of nuclear power; ensuring and enhancing the safety of operating plants; dealing with nuclear power plants built

Conference on the Safety of Nuclear Power (cont.)

to earlier safety standards; the next generation of nuclear power plants; and final disposal of radioactive wastes.

Conclusions and recommendations for each of these issues were developed in the discussions which took place and, additionally, the conference agreed on ten major findings, including recommendations for Agency actions to enhance nuclear safety and the consideration of an integrated international approach to take into account all aspects of nuclear safety through the mechanism of an international convention.

Publications

Series and No.	Title
IAEA-TECDOC-589	Analysis of replies to an IAEA questionnaire on inspection and enforcement by the regulatory body for nuclear power plants
IAEA/WCRT/SRA/1	Water cooled reactor technology: Safety research abstracts No. 1

Safe siting and design of nuclear installations

Engineering safety review services

Several site/seismic safety review missions carried out in 1991 were follow-up activities of recommendations made in earlier missions in 1990. New reviews involved two sites (Indonesia and Tunisia), one plant under construction (Crimea, USSR) and one in operation (Bohunice, Czechoslovakia).

Engineering safety review services related to site and external hazards

Country	Site/plant	Service
Indonesia	Muria Peninsula	Site selection specifications review
Bulgaria	Kozloduy	Seismic safety review — limited plant inspection
Bulgaria	Belene/Kozloduy	Interim review of external hazard studies
Tunisia	Northwest coast of Tunisia	Review of tectonic stability and seismicity
USSR	Crimea	Seismic safety review — limited to seismic input
Czechoslovakia	Bohunice	Limited scope seismic safety review
Czechoslovakia	Temelin	Review of work plans for site safety

Engineering safety training services related to site and external hazards

Country	Site/plant	Service
Indonesia	Muria Peninsula	Workshop on environmental impact of nuclear power plants
Bulgaria	Kozloduy/Belene	Workshop on quality assurance for design against external hazards
Czechoslovakia	Temelin	Workshop on quality assurance for design against external hazards
Romania	Cernavoda	Workshop on seismic design methodologies
Tunisia	Tunis	Workshop on quality assurance for nuclear power plant siting

Evaluation of advanced plant designs

The evaluation of advanced plant designs from the safety viewpoint was initiated. A preliminary approach to the safety concepts for future nuclear power plants was developed and published in the 1991 edition of the Nuclear Safety Review. The first Technical Committee meeting to review the safety features of new reactor designs was convened in November.

Guidance on software important to safety

To help ensure that software based systems contribute to, rather than compromise, safety, a programme was initiated to provide guidance for software in applications important to safety in nuclear power plants. A state of the art report on safety critical software is now being prepared. This report will examine 14 safety issues in software engineering as identified by an Advisory Group. It is intended to serve as a technical basis for the development of a Safety Guide on software.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Seismic data for the siting and site revalidation of nuclear facilities	1992	7

Publications

Series and No.	Title
Safety Series No. 50-SG-D7 (Rev. 1)	Emergency power systems at nuclear power plants: a safety guide
Safety Series No. 50-SG-S1 (Rev. 1)	Earthquakes and associated topics in relation to nuclear power plant siting

Operational safety of nuclear power plants

INES

The trial implementation period of the International Nuclear Event Scale (INES) has now ended. Thirty Member States are already committed to its use; it was recently extended to all types of nuclear activities, such as electricity production, fuel reprocessing, transportation and waste management.

Almost 100 events were disseminated in 1991 by the INES information system to assist INES national officers in informing their public about events that occurred in other countries.

At an Advisory Group meeting that gathered INES national officers from participating Member States, the Event Rating Form, part of the INES Information System, was improved by the inclusion of additional information for public information purposes. Also, information delays in communicating events and the criteria used for reporting events were confirmed.

IRS

In 1991, China joined the Agency's Incident Reporting System (IRS) with observer status, making a total of 26 Member States as participants. By the end of 1991, the IRS database contained 1220 records. One hundred and thirty nine reports were received during the year. The IRS database was distributed to participants on diskettes and updated quarterly.

Exchange of operational experience with PHWRs

The second biennial meeting on the subject of the exchange of safety experience with PHWRs was held in Argentina under the joint sponsorship of the Agency and the CANDU Owners Group (COG). Over 80 participants from Argentina, Canada, India, Japan, the Republic of Korea, Pakistan and Romania attended. The technical sessions covered event oriented lessons, plant operational safety, and operations, commissioning and design good practices.

Numerical indicators of nuclear safety

The work carried out during 1991 on numerical indicators of nuclear safety included a series of topical meetings on the Plant Specific Safety Indicator System, which resulted in the preparation of a document defining more than 70 individual indicators. A Technical Committee meeting on experience with plant specific safety indicators was attended by experts from 20 countries.

Safety aspects of maintenance at nuclear power plants

The safety impact of maintenance at nuclear power plants and the different approaches used to optimize such maintenance were discussed at a Technical Committee meeting in which more than 70 experts from 24 countries and international organizations participated. The importance of adequate maintenance programmes to improve nuclear power plant safety was stressed and different optimization methods, including reliability centred maintenance and risk focused maintenance, were discussed.

The importance of modern diagnostic systems used to determine the status of safety related components was discussed at a Technical Committee meeting. The role of these systems in the management of ageing, as well as backfitting of older plants, was examined, with emphasis on the situation at nuclear power plants with WWER-440 reactors.

Nuclear power plant ageing

Work leading to pilot studies on the management of ageing of nuclear power plant components and involving participants from 18 Member States, the CEC, OECD/NEA and WANO, was completed in 1991. These studies will develop strategies for managing ageing for four representative plant components: the

Nuclear power plant ageing (cont.)

primary nozzle of the reactor pressure vessel, a motor operated valve, the concrete containment building and instrumentation and control cables. These components, representing different safety functions and materials, were selected on the basis of their safety significance and their susceptibility to different types of ageing degradation.

Publications

Series and No.	Title
Safety Series No. 50-SG-O1 (Rev. 1)	Staffing of nuclear power plants and the recruitment, training and authorization of operating personnel

Operational safety services to nuclear power plants

Operational safety services

Operational safety review missions (Pre-OSART, OSART and Safety Review Missions) conducted during 1991 have, on different occasions, shown the need for: fundamental organizational changes, application of modern management techniques, introduction of comprehensive quality assurance programmes, improved training, more qualified operators in the control rooms, improved quality of operating procedures, especially emergency operating procedures, improved housekeeping and the need to reinforce industrial safety practices. In one exceptional case, imperative repairs to safety related equipment were identified. Follow-Up Visits showed that the recommendations and suggestions of Pre-OSART and OSART missions were being taken seriously by power plant managements and had resulted in improvements in operational safety. The vast majority of the actions were categorized either as completed or as having achieved satisfactory progress towards completion.

OSART and Pre-OSART guidelines were revised. A number of OSART review topics were developed in greater detail and produced as supplementary guidance and reference material. Pre-OSART good practices for 1986–1989 were collated and were being prepared for publication.

OSART/Pre-OSART missions conducted in 1991

Country	Plant	Type	Power MW(e)
Sweden	Ringhals Units 3 and 4	PWR	2 × 960
China	Guangdong	PWR	2 × 985
Bulgaria	Kozloduy Unit 5	WWER	1000
South Africa	Koeberg	PWR	2 × 921
Germany	Grafenrheinfeld	PWR	1235

Technical Exchange Visits conducted in 1991

Country	Plant	Type	Power MW(e)
Czechoslovakia	Dukovany Units 1–4	WWER	4 × 440

Follow-Up Visits for OSART/Pre-OSART missions conducted in 1991

Country	Plant	Type	Power MW(e)
China	Qinshan	PWR	300
Hungary	Paks Units 1–4	WWER	4 × 440
Sweden	Oskarshamn Unit 1	BWR	440
Spain	Cofrentes	BWR	974
Romania	Cernavoda	PHWR	5 × 700

ASSET

The Assessment of Safety Significant Events Team (ASSET) programme continued to receive the attention of many countries. The 1991 Conference on the Safety of Nuclear Power assessed the results of these activities and recommended that the Agency expand the ASSET programme, along with the OSART programme, to support the overview process with the objective of achieving a high level of safety performance in all operating plants.

Two ASSET missions to the Kola and Novovoronezh plants in the USSR completed the series of five ASSET missions to all plants with the first generation Soviet designed 440 MW(e) Model 230 WWERs. On the basis of the findings of these missions, an action plan was elaborated to improve the operational safety of the older WWERs in order to compensate for some key design deficiencies. These recommended actions were also included in the WANO programme for the enhancement of safety at plants with older WWERs.

Further development of ASSET methodology aimed at enhancing the usefulness of the programme followed two directions: (1) developing guidance on how to set up effective plant programmes for the prevention of incidents and to receive feedback, and (2) computerization of the ASSET root cause analysis procedure.

ASSET missions in 1991

Country	Plant
Pakistan (2)	Karachi
Belgium	Tihange/Doel
Spain	Trillo
Mexico	Laguna Verde
Republic of Korea	Seoul/Taejon
Netherlands	The Hague
USSR	Kola
USSR	Novovoronezh
USSR	Kiev
Sweden	Stockholm

At the request of national regulatory and operating organizations, training in the ASSET methodology was expanded. Seminars on the basis of a standard programme were conducted in six countries. By the end of 1991, the number of operators and regulators in the world, including those at the managerial level, who received ASSET training totalled more than 200.

WWER-440 Model 230 Project

The Agency's WWER-440/230 Project, implemented in 1990, continued in 1991. The Agency conducted a review of the design concept of WWER-440/230 nuclear power plants with the help of more than 50 specialists. The design concept review pointed to differences between various WWER-440/230 plants, confirming the importance of plant specific review missions. Safety Review Missions were conducted to all four sites with WWER-440/230 plants in operation, i.e. Bohunice Units 1 and 2 (Czechoslovakia), Kozloduy Units 1-4 (Bulgaria), Novovoronezh Units 3 and 4 and Kola Units 1 and 2 (both USSR) between April and September. These reviews, by teams of about 15 experts, assessed the plant specific design deficiencies as well as the overall conduct of operations. The scope of the reviews comprised core design, system analysis, component integrity, instrumentation and control, electric power, accident analysis, plant management and organization, training and qualification, maintenance, fire protection, and emergency planning and preparedness.

WWER-440 Model 230 Project (cont.)

ASSET missions have also been carried out at all WWER-440/230 plants in operation, including Greifswald Units 1–4, to review the operational experience of 160 reactor-years accumulated by these plants and to assess the appropriateness and completeness of corrective actions taken by plant management to prevent recurrences of incidents.

In addition, the Agency has carried out Safety Review Missions to the Bohunice and Kozloduy sites to review the safety of these plants against seismic hazards, emphasizing earthquake design acceleration and the seismic vulnerability of structures and components important to safety.

In order to assist the governments of Member States concerned in setting priorities for the corrective measures required at their plants, two project review meetings were convened by the Agency in Vienna. About 1300 specific safety items identified during the Safety Review Missions and in the conceptual design review and stored in the database were grouped into broader categories representing some 100 issues of safety concern and analysed further. The meeting report prepared by a group of international experts and Agency staff evaluated the safety significance of the issues and established the technical basis for short and long term programmes required to improve the safety of WWER-440/230 nuclear power plants. The Project has extrabudgetary funding.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on evaluation and feedback of safety related experience in nuclear power plant operation	Canada and USA	30	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-596	Reviewing operational experience feedback: supplementary guidance and reference material for IAEA OSARTs
IAEA-TECDOC-600	Numerical indicators of nuclear power plant safety performance
IAEA-TECDOC-605	OSART good practices: 1986–1989
IAEA-TECDOC-632	ASSET guidelines: revised 1991 edition

Management and mitigation of accidents in nuclear power plants

The final draft of a manual for preplanning accident management in nuclear power plants was completed and distributed for review to experts in the field. The main emphasis is on generic accident management guidelines, including the evaluation of vulnerabilities, accident management strategies, symptom oriented emergency operating procedures, and systems utilization, training and organization.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Severe accident management	1991	11
1989	Containment integrity and effectiveness for accident conditions beyond design basis	1992	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the prevention and mitigation of severe accidents in nuclear power plants	USA, Canada	31	5 weeks
National course on accident management	Mexico	42	2 weeks
National course on accident management	South Africa	71	2 weeks
National course on accident management	Rep. of Korea	39	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-586	Simulation of a loss of coolant accident with rupture of the steam generator hot collector

Research reactor safety

INSARR

During 1991 the Agency conducted INSARR (Integrated Safety Assessment of Research Reactors) missions in Ukraine, Chile (two reactors) and Brazil.

Operational safety experience with research reactors

Continuing the initiative of the European Atomic Energy Society (EAES) to establish a research reactor operator group (RROG) to review operational safety matters and promote the exchange of experience in Europe and elsewhere, the 2nd EAES/RROG Annual Meeting was held in Würenlingen, Switzerland. The Agency participated, together with the CEC and delegates from nine countries. In addition to the national reports, the meeting's agenda included three other topics: performance indicators, personnel and fuel cycle.

PSA for research reactors

One of the most serious problems with probabilistic safety assessment (PSA) studies of research reactors is the lack of reliable data. To deal with this issue, the Agency initiated a CRP on data acquisition for research reactor PSAs. The first product of the CRP, which was a joint effort of all ten countries participating, was a manual on reliability data collection for PSAs for research reactors, which was finalized during 1991.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Data acquisition for research reactor PSA studies	1992	10

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on regulatory aspects and safety documentation of research reactors	Chile	23	3 weeks
Course on the safe operation of research reactors	Islamic Republic of Iran	24	3 weeks

Safety assessment of nuclear facilities

PSAPACK

PSAPACK is an integrated, PC based computer code which includes a number of functions necessary for carrying out a level 1 PSA (i.e. calculating core damage probabilities based on the analysis of accident sequences). A users' manual was prepared and the performance of the fault tree analyser was significantly upgraded to permit the solving of full scale problems.

PSA applications

The Agency's PSA programme and assistance activities are expanding in the area of PSA applications, including the use of PSA for operational safety management. A number of case studies were prepared in a uniform format by internationally recognized experts. While the focus of these case studies is on PSA applications, methodological issues and review aspects have also been discussed. Four case studies were published in 1991 in the IAEA-TECDOC series. With three published earlier (1989-1990) and the six remaining being finalized, the entire case study programme will be completed in 1992.

PSAs for shutdowns and low power conditions

With a few exceptions, current PSAs do not include modelling of accident sequences during shutdown and low power conditions. Such modes of operation may constitute significant contributions to the overall risk, as indicated by some recent studies, as well as by a number of incidents at nuclear power plants. Moreover, the methodology for the treatment of off-power modes of operation is not well established. A draft report providing an overview of the approaches to the modelling of accident sequences during shutdown and low power conditions was prepared.

IPERS

Three International Peer Review Service (IPERS) missions reviewed the progress of level 1 PSAs at the Dodewaard plant in the Netherlands, Kori 3 and 4 in the Republic of Korea and a level 2 PSA at Borssele in the Netherlands. Generic findings from six IPERS missions carried out in 1989 and 1990 were compiled, providing modelling insights for PSA practitioners. Procedures for IPERS were expanded to reflect the insights and to include guidelines for level 2 PSA reviews.

Symposium

The Agency organized, jointly with the American Nuclear Society, European Nuclear Society and OECD/NEA, a symposium on the use of probabilistic safety assessment for operational safety (PSA '91).

This symposium, organized with the aim of providing a forum for discussing the major achievements of PSA and its future directions, attracted around 250 participants representing 32 Member States and 4 international organizations. Sixty-one papers and 27 posters were presented covering such areas as experience with 'living' PSAs, applications in decision making, use of PSA for evaluating operating experience, for operator training, in accident management and for probabilistic safety criteria.

The purpose of the symposium was to present practical experience in the use of PSA for operational safety, with special emphasis on the state of the art in improving safety and the lessons learned from PSAs already performed.

Decision aiding techniques in nuclear safety and radiation protection

A Technical Committee meeting was held to demonstrate the extent of applicability of decision aiding techniques in the field of nuclear safety and radiation protection. The meeting was conducted in a workshop style to encourage the involvement of the maximum number of participants during discussions; it was highlighted that assisting the complex decision making process in the field of nuclear safety and radiation protection, waste management and decommissioning requires extension to other areas of public and occupational safety.

Human factors: safety culture missions

The concept of safety culture was developed by the International Safety Advisory Group (INSAG) in publication SS-75-INSAG 4. A consultants meeting was held in 1991 with the objective of framing a method of assessing the effectiveness of the safety culture at a plant, perhaps as a separate mission or as a component of an existing review format, such as OSART or ASSET. The consultants took the view that organizational and management framework aspects were already covered by existing review methodologies, such as OSART. Deliberations were thus concentrated on the less tangible aspects, such as climate and attitude. It was concluded that it might be possible to present a number of questions to the plant management team, and further questions to a cross-section of station staff, the responses to which would reveal the extent to which the plant had an effective safety culture. It was felt that the assessment team should consist of two or three people with a sound knowledge of nuclear power plant operation and of the principles of nuclear safety and safety culture. The assessment would take one week at the plant site.

Human performance indicators

The Agency initiated a programme with the intention of stimulating the identification of performance indicators associated with human factors and plant personnel performance. Human performance indicators are intended to provide the best available compilation of objective indicators to assist plant management in the assessment of operational safety, safety attitude, management quality and the need for further improvements.

Human factors in IRS

In 1991, the topic of maintenance related incidents with human factor aspects was chosen for study. Four hundred of the most recent IRS reports were examined, a significant number of these events (about 25%) being maintenance related incidents with human factor aspects. Root cause analysis identified procedural and management/organizational deficiencies as main contributors to the category of objective causes, i.e. errors or deficiencies not directly related to the person performing the maintenance activity. Other objective causes made only minor contributions. With respect to subjective causes, the main contributors were found to be simple human failures, errors or mistakes caused by carelessness.

Organization and management

At a consultants meeting organized jointly by the Agency and IIASA, a provisional framework for good management principles was designed, emphasizing the continuous improvement of practices through internal and external feedback mechanisms rather than by the analysis of the particular content of the practices themselves.

Nuclear power plant automation and robotics

A Technical Committee meeting on the safety implications of plant automation and robotics was organized in Vienna. It was concluded at the meeting that robots: have already replaced manual activities involving complicated or dangerous access (i.e. radiation); perform work which is repetitive or which

Nuclear power plant automation and robotics
(cont.)

requires continuous attention; and perform special purpose tasks with the aim of reducing human factor problems. Other conclusions were that automation technology had made very rapid progress, slowly permeating into nearly all activities at nuclear power plants, and that there was a need to assure a reasonable balance in power plant design and operation between automation and human control so as to ensure both maximum safety and availability.

Publications

Series and No.	Title
Proceedings Series	Balancing automation and human action in nuclear power plants
Safety Series No. 75-INSAG-4	Safety culture
INSAG Technical Note No. 3	A review of the report 'IAEA safety targets and probabilistic risk assessment
IAEA-TECDOC-581	Safety implications of computerized process control in nuclear power plants
IAEA-TECDOC-590	Case study on the use of PSA methods: determining safety importance of systems and components at nuclear power plants
IAEA-TECDOC-591	Case study on the use of PSA methods: backfitting decisions
IAEA-TECDOC-592	Case study on the use of PSA methods: human reliability analysis
IAEA-TECDOC-593	Case study on the use of PSA methods: station blackout risk at Millstone Unit 3
IAEA-TECDOC-599	Use of probabilistic safety assessment to evaluate nuclear power plant technical specifications
IAEA-TECDOC-611	Use of plant specific PSA to evaluate incidents at nuclear power plants
IAEA-TECDOC-618	Human reliability data collection and modelling

Safeguards

Safeguards statement

In carrying out the safeguards obligations of the Agency in 1991, the Secretariat did not detect any event which would indicate the diversion of a significant amount of nuclear material placed under Agency safeguards — or, with regard to certain agreements, the misuse of facilities, equipment or non-nuclear material subject to safeguards — for the manufacture of any nuclear weapon, or for any other military purpose, or for the manufacture of any other nuclear explosive device, or for purposes unknown.[1]

Inspection activities carried out pursuant to United Nations Security Council Resolution 687 revealed that Iraq had not complied with the obligations under its safeguards agreement to declare certain nuclear activities and place all relevant nuclear material under safeguards.

However, it is considered reasonable to conclude that the nuclear material placed under Agency safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for. This statement is derived from safeguards activities conducted in the field and at Headquarters and information provided in reports submitted by States.

It has been recognized that, owing to limitations in the information available to the Agency and in the existing safeguards practices, non-compliance with agreements could occur without detection by the Agency, particularly at non-declared facilities. The Agency has, as a matter of urgency, examined these limitations and measures to strengthen the safeguards system have been proposed. The right to conduct special inspections in accordance with the provisions of comprehensive safeguards agreements has been reaffirmed by the Board of Governors, and proposals for significantly expanding the flow of information into the safeguards system are under discussion. At the end of 1991, as a result of severe financial constraints imposed on the Agency, the Secretariat began to experience difficulties in maintaining the safeguards programme. Continuation of these constraints will have negative effects on Agency safeguards implementation.

Safeguards coverage

As of 31 December 1991, 180 safeguards agreements were in force with 105 States (and with Taiwan, China), compared with 177 agreements with 104 States (and with Taiwan, China) at the end of 1990.

Safeguards agreements pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force with Tuvalu in March and with South Africa in September.

A unilateral submission agreement with Pakistan for the application of safeguards to a miniature neutron source reactor supplied by China entered into force in September.

The Board of Governors approved draft safeguards agreements pursuant to NPT with the Democratic People's Republic of Korea, St. Vincent and the Grenadines and the Solomon Islands. These agreements had not entered into force at the end of 1991.

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[1] In the case of voluntary-offer agreements with nuclear-weapon States, nuclear material subject to safeguards was not withdrawn from safeguards except in conformity with these agreements.

Safeguards coverage (cont.)

Argentina and Brazil established a Common System of Accounting and Control of Nuclear Materials (SCCC) and a Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) whose objective is to administer and implement the SCCC. A comprehensive safeguards agreement was negotiated between the Governments of Argentina and Brazil, the ABACC and the Agency, covering all nuclear materials in all nuclear activities carried out within the territories of the two States, under their jurisdiction or under their control anywhere. This agreement, which is compatible with the Treaty of Tlatelolco, was signed in December and will enter into force when the Agency receives from the ABACC and from the States Parties written notification that the respective requirements for entry into force have been met.

During 1991 safeguards were applied in 41 States under agreements pursuant to NPT or to NPT and the Treaty of Tlatelolco, in one State under an agreement pursuant to the Treaty of Tlatelolco and in ten States under INFCIRC/66/Rev.2-type agreements; at the end of 1991 safeguards in one of these ten States were being applied pursuant to NPT. Safeguards activities pursuant to NPT in Iraq were subsumed by activities carried out pursuant to Security Council Resolution 687. (The Agency also applies safeguards to nuclear installations in Taiwan, China.)

Each State that concludes a comprehensive safeguards agreement with the Agency undertakes to accept "safeguards, in accordance with the terms of the agreement, on all source or special fissionable material in all peaceful nuclear activities..." In 1991 the Board of Governors concluded, on the basis of inspections and from information obtained from the Iraqi authorities in the course of the inspections, that Iraq had violated this undertaking by not submitting to the Agency information regarding nuclear material and certain facilities in its uranium enrichment programme.

Safeguards agreements based on the guidelines contained in INFCIRC/66/Rev. 2 require that safeguards be applied to the nuclear material, facilities, equipment and non-nuclear material — and with regard to certain technological information — specified in them. In some States with such agreements, unsafeguarded facilities were known in 1991, as in earlier years, to be in operation or under construction. In the case of nuclear-weapon States safeguards agreements do not provide for safeguards on all nuclear material, and these States have unsafeguarded nuclear facilities.

Voluntary-offer agreements were in force with the five nuclear-weapon States. In accordance with the agreements with four of these States, certain facilities were designated by the Agency for inspection and were inspected. In one of these States, safeguards were also applied at some facilities under INFCIRC/66/Rev.2-type agreements. Preparations continued for the implementation of safeguards pursuant to the voluntary-offer agreement concluded with the fifth nuclear-weapon State, and a facility has been selected for inspection.

Number of States having significant nuclear activities at the end of the year indicated

	Number of States		
	1989	1990	1991
States with safeguards applied under NPT or NPT/Tlatelolco agreements	42	42	43[a]
States with safeguards applied under Tlatelolco agreements	1	1	1
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[b]	10	9	8
Nuclear-weapon States with safeguards applied under voluntary-offer agreements[c]	4	4	4
Other nuclear-weapon States	1	1	1
Total number of States with significant nuclear activities	58	57	57

[a] This includes Iraq, where safeguards activities in 1991 were subsumed by activities carried out pursuant to Security Council Resolution 687.

[b] Some States with INFCIRC/66/Rev.2-type agreements which have not yet been suspended, although NPT agreements have entered into force, are listed under NPT agreements only. Nuclear-weapon States with INFCIRC/66/Rev.2-type agreements in force are not included. Safeguards are also applied to nuclear installations in Taiwan, China.

[c] The status of States formerly part of the USSR is presently under consideration.

Status of agreements pursuant to treaty obligations

As of 31 December 1991, safeguards agreements were in force with 88 States pursuant to NPT. For 48 non-nuclear-weapon States party to NPT there was no safeguards agreement in force in accordance with Article III.4 of the Treaty. As far as the Agency was aware, only two of these States had significant nuclear activities. Safeguards were being applied in these States pursuant to other agreements pending the entry into force of a safeguards agreement pursuant to NPT.

NPT safeguards agreements have already been concluded with all eleven signatories of the South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty), and safeguards were applied in one of these States pursuant to such an agreement.

Nineteen of the 23 Latin American States party to the Treaty of Tlatelolco have concluded agreements with the Agency pursuant to that Treaty and 16 of these agreements are in force. Two States with territories in the zone of application of the Treaty of Tlatelolco have also concluded similar agreements.

Security Council Resolution 687

In Resolution 687, adopted by the Security Council of the United Nations in April, the Security Council requested the Agency to carry out immediate on-site inspection of Iraq's nuclear capabilities and to develop and carry out a plan for the destruction, removal or rendering harmless, as appropriate, of all nuclear weapons and nuclear-weapons-usable material or any subsystems or components or any research, development, support or manufacturing facilities related thereto. It also required the Agency to develop for the approval of the Security Council a plan for the future ongoing monitoring and verification of Iraq's compliance with its obligations under Resolution 687, including an inventory of all nuclear material in Iraq subject to the Agency's verification and inspections to confirm that the Agency's safeguards cover all relevant nuclear activities in Iraq.

During 1991 the Agency carried out eight inspections in Iraq and prepared a plan for the destruction, removal, or rendering harmless of the items referred to above, which was approved by the Security Council. The Agency also developed a plan for the future ongoing monitoring and verification of Iraq's compliance with Resolution 687 as well as the related Resolution 707. This plan was approved by Security Council Resolution 715.

Situation on 31 December 1991 with respect to the conclusion of safeguards agreements between the Agency and non-nuclear-weapon States in connection with NPT

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Afghanistan	4 February 1970	In force: 20 February 1978	257
Albania	12 September 1990		
Antigua and Barbuda[b]	1 November 1981	Signed: 1 February 1990	
Australia	23 January 1973	In force: 10 July 1974	217
Austria	27 June 1969	In force: 23 July 1972	156
Bahamas	10 July 1973		
Bahrain	5 November 1988		
Bangladesh	27 September 1979	In force: 11 June 1982	301
Barbados	21 February 1980		
Belgium	2 May 1975	In force: 21 February 1977	193
Belize	9 August 1985	Approved by the Board, Feb.1986	
Benin	31 October 1972		
Bhutan	23 May 1985	In force: 24 October 1989	371
Bolivia[b]	26 May 1970	Signed: 23 August 1974	
Botswana	28 April 1969		
Brunei Darussalam	25 March 1985	In force: 4 November 1987	365
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
Cameroon	8 January 1969		
Canada	8 January 1969	In force: 21 February 1972	164
Cape Verde	24 October 1979		
Central African Republic	25 October 1970		
Chad	10 March 1971		
Colombia	8 April 1986		
Congo	23 October 1978		
Costa Rica[b]	3 March 1970	In force: 22 November 1979	278
Côte d'Ivoire	6 March 1973	In force: 8 September 1983	309
Cyprus	10 February 1970	In force: 26 January 1973	189
Czechoslovakia	22 July 1969	In force: 3 March 1972	173
Democratic Kampuchea	2 June 1972		
Democratic People's Republic of Korea	12 December 1985	Approved by the Board, Sep.1991	
Denmark[c]	3 January 1969	In force: 21 February 1977	193
Dominica	10 August 1984		
Dominican Republic[b]	24 July 1971	In force: 11 October 1973	201
Ecuador[b]	7 March 1969	In force: 10 March 1975	231
Egypt	26 February 1981	In force: 30 June 1982	302
El Salvador[b]	11 July 1972	In force: 22 April 1975	232
Equatorial Guinea	1 November 1984	Approved by the Board, June 1986	
Ethiopia	5 February 1970	In force: 2 December 1977	261

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Fiji	14 July 1972	In force: 22 March 1973	192
Finland	5 February 1969	In force: 9 February 1972	155
Gabon	19 February 1974	Signed: 3 December 1979	
Gambia	12 May 1975	In force: 8 August 1978	277
Germany[d]	2 May 1975	In force: 21 February 1977	193
Ghana	5 May 1970	In force: 17 February 1975	226
Greece[c]	11 March 1970	Accession: 17 December 1981	193
Grenada	19 August 1974		
Guatemala[b]	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Haiti[b]	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras[b]	16 May 1973	In force: 18 April 1975	235
Hungary	27 May 1969	In force: 30 March 1972	174
Iceland	18 July 1969	In force: 16 October 1974	215
Indonesia	12 July 1979	In force: 14 July 1980	283
Iran, Islamic Republic of	2 February 1970	In force: 15 May 1974	214
Iraq	29 October 1969	In force: 29 February 1972	172
Ireland	1 July 1968	In force: 21 February 1977	193
Italy	2 May 1975	In force: 21 February 1977	193
Jamaica[b]	5 March 1970	In force: 6 November 1978	265
Japan	8 June 1976	In force: 2 December 1977	255
Jordan	11 February 1970	In force: 21 February 1978	258
Kenya	11 June 1970		
Kiribati	18 April 1985	In force: 19 December 1990	390
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait	17 November 1989		
Lao People's Democratic Republic	20 February 1970	Signed: 22 November 1991	
Lebanon	15 July 1970	In force: 5 March 1973	191
Lesotho	20 May 1970	In force: 12 June 1973	199
Liberia	5 March 1970		
Libyan Arab Jamahiriya	26 May 1975	In force: 8 July 1980	282
Liechtenstein	20 April 1978	In force: 4 October 1979	275
Lithuania	23 September 1991		
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malawi	18 February 1986		
Malaysia	5 March 1970	In force: 29 February 1972	182
Maldives	7 April 1970	In force: 2 October 1977	253
Mali	10 February 1970		
Malta	6 February 1970	In force: 13 November 1990	387
Mauritius	25 April 1969	In force: 31 January 1973	190
Mexico[b]	21 January 1969	In force: 14 September 1973	197
Mongolia	14 May 1969	In force: 5 September 1972	188

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Morocco	27 November 1970	In force: 18 February 1975	228
Mozambique	4 September 1990		
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[f]	2 May 1975	In force: 21 February 1977	193
New Zealand	10 September 1969	In force: 29 February 1972	185
Nicaragua[b]	6 March 1973	In force: 29 December 1976	246
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Panama[b]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay[b]	4 February 1970	In force: 20 March 1979	279
Peru[b]	3 March 1970	In force: 1 August 1979	273
Philippines	5 October 1972	In force: 16 October 1974	216
Poland	12 June 1969	In force: 11 October 1972	179
Portugal[g]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St. Lucia	28 December 1979	In force: 2 February 1990	379
St. Vincent and the Grenadines	6 November 1984	Approved by the Board, Sep.1991	
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	Approved by the Board, Feb.1977	
São Tome and Principe	20 July 1983		
Saudi Arabia	3 October 1988		
Senegal	17 December 1970	In force: 14 January 1980	276
Seychelles	12 March 1985		
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	259
Solomon Islands	17 June 1981	Approved by the Board, Feb.1991	
Somalia	5 March 1970		
South Africa	10 July 1991	In force: 16 September 1991	394
Spain	5 November 1987	Accession: 5 April 1989	193
Sri Lanka	5 March 1979	In force: 6 August 1984	320
Sudan	31 October 1973	In force: 7 January 1977	245
Suriname[b]	30 June 1976	In force: 2 February 1979	269
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden	9 January 1970	In force: 14 April 1975	234
Switzerland	9 March 1977	In force: 6 September 1978	264
Syrian Arab Republic	24 September 1969		
Tanzania	7 June 1991		
Thailand	7 December 1972	In force: 16 May 1974	241
Togo	26 February 1970	Signed: 29 November 1990	
Tonga	7 July 1971	Approved by the Board, Feb.1975	
Trinidad and Tobago	30 October 1986		

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Tunisia	26 February 1970	In force: 13 March 1990	381
Turkey	17 April 1980	In force: 1 September 1981	295
Tuvalu	19 January 1979	In force: 15 March 1991	391
Uganda	20 October 1982		
Uruguay[b]	31 August 1970	In force: 17 September 1976	157
Venezuela[b]	26 September 1975	In force: 11 March 1982	300
Viet Nam	14 June 1982	In force: 23 February 1990	376
Yemen, Republic of	1 June 1979		
Yugoslavia	3 March 1970	In force: 28 December 1973	204
Zaire	4 August 1970	In force: 9 November 1972	183
Zambia	15 May 1991		
Zimbabwe	26 September 1991		

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[a] The information reproduced in columns (1) and (2) was provided to the Agency by depository Governments of NPT, and an entry in column (1) does not imply the expression of any opinion on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers. The Table does not contain information relating to the participation of Taiwan, China, in NPT.

[b] The relevant safeguards agreement refers to both NPT and the Treaty of Tlatelolco.

[c] The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands. Upon Greenland's secession from EURATOM as of 31 January 1985, the Agreement between the Agency and Denmark (INFCIRC/176) re-entered into force as to Greenland.

[d] The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.

[e] The application of Agency safeguards in Greece under the agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, on which date Greece acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

[f] An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.

[g] The NPT safeguards agreement with Portugal (INFCIRC/272), in force since 14 June 1979, was suspended on 1 July 1986, on which date Portugal acceded to the agreement between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency of 5 April 1973 (INFCIRC/193).

Situation on 31 December 1991 with respect to the conclusion of safeguards agreements between the Agency and States party to the Treaty of Tlatelolco[a]

States party to the Treaty of Tlatelolco (1)	Date of becoming a party to the Treaty of Tlatelolco (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Antigua and Barbuda[b]	11 October 1983	Signed: 1 February 1990	
Bahamas	26 April 1977		
Barbados	25 April 1969		
Bolivia[b]	18 February 1969	Signed : 23 August 1974	
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica[b]	25 August 1969	In force: 22 November 1979	278
Dominican Republic[b]	14 June 1968	In force: 11 October 1973	201
Ecuador[b]	11 February 1969	In force: 10 March 1975	231
El Salvador[b]	22 April 1968	In force: 22 April 1975	232
Grenada	20 June 1975		
Guatemala[b]	6 February 1970	In force: 1 February 1982	299
Haiti[b]	23 May 1969	Signed : 6 January 1975	
Honduras[b]	23 September 1968	In force: 18 April 1975	235
Jamaica[b]	26 June 1969	In force: 6 November 1978	265
Mexico[b, c]	20 September 1967	In force: 14 September 1973	197
Nicaragua[b]	24 October 1968	In force: 29 December 1976	246
Panama[d]	11 June 1971	In force: 23 March 1984	316
Paraguay[b]	19 March 1969	In force: 20 March 1979	279
Peru[b]	4 March 1969	In force: 1 August 1979	273
Suriname[b]	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago	27 June 1975		
Uruguay[b]	20 August 1968	In force: 17 September 1976	157
Venezuela[b]	23 March 1970	In force: 11 March 1982	300
In addition, there are the following safeguards agreements with States party to Additional Protocol I to the Treaty:[e]			
	Netherlands[b]	In force: 5 June 1975	229
	United States of America	In force: 6 April 1989	366

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[a] The information reproduced in columns (1) and (2) was taken from the relevant OPANAL status report.

In addition to the States listed in column (1), Argentina has signed the Treaty but not ratified it, while Brazil and Chile have ratified it but have not yet become parties to the Treaty as they have not so far made the declaration provided for in Article 28 of the Treaty. Dominica signed the Treaty on 2 May 1989.

[b] The relevant safeguards agreement refers to both the Treaty of Tlatelolco and NPT.

[c] The application of safeguards under an agreement with Mexico in connection with the Treaty of Tlatelolco which entered into force on 6 September 1968 (INFCIRC/118) was suspended after the conclusion of an agreement with Mexico in connection with both the Treaty of Tlatelolco and NPT (INFCIRC/197).

[d] An agreement has also been concluded in 1988 pursuant to both the Treaty of Tlatelolco and NPT; this has not yet entered into force.

[e] Additional Protocol I refers to States outside Latin America which have de jure or de facto jurisdiction over territories within the limits of the geographical zone established in the Treaty.

Agreements providing for safeguards, other than those in connection with NPT or the Treaty of Tlatelolco, approved by the Board as of 31 December 1991

Party(ies)[a]	Subject	Entry into force	INFCIRC
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
(a) *Project agreements*			
Albania	Research reactor and fuel therefor	Approved by the Board, June 1991	
Argentina	Siemens SUR-100	13 March 1970	143
	RAEP Reactor	2 December 1964	62
Chile	Herald Reactor	19 December 1969	137
Finland[b]	FiR-1 Reactor	30 December 1960	24
	FINN sub-critical assembly	30 July 1963	53
Ghana	Research reactor and fuel therefor	Approved by the Board, Dec.1991	
Greece[b]	GRR-1 Reactor	1 March 1972	163
Indonesia[b]	Additional core-load for TRIGA Reactor	19 December 1969	136
Iran, Islamic Republic of[b]	UTRR Reactor	10 May 1967	97
Jamaica[b]	Fuel for research reactor	25 January 1984	315
Japan[b]	JRR-3	24 March 1959	3
Malaysia[b]	TRIGA-II Reactor	22 September 1980	287
Mexico[b]	TRIGA-III Reactor	18 December 1963	52
	Siemens SUR-100	21 December 1971	162
	Laguna Verde Nuclear Power Plant	12 February 1974	203
Morocco[b]	Fuel for research reactor	2 December 1983	313
Pakistan	PRR Reactor	5 March 1962	34
	Booster rods for KANUPP	17 June 1968	116
Peru[b]	Research reactor and fuel therefor	9 May 1978	266
Philippines[b]	PRR-1 Reactor	28 September 1966	88
Romania[b]	TRIGA Reactor	30 March 1973	206
	Experimental fuel elements	1 July 1983	307
Spain[b]	Coral-I Reactor	23 June 1967	99
Thailand[b]/United States of America	Fuel for research reactor	30 September 1986	342
Turkey[b]	Sub-critical assembly	17 May 1974	212
Uruguay[b]	URR Reactor	24 September 1965	67
Venezuela[b]	RV-1 Reactor	7 November 1975	238
Viet Nam[c]	Fuel for research reactor	1 July 1983	308
Yugoslavia[b]	TRIGA-II Reactor	4 October 1961	32
	Krško Nuclear Power Plant	14 June 1974	213
Zaire[b]	TRICO Reactor	27 June 1962	37
	Fuel for research reactor	20 September 1990	389
(b) *Unilateral submissions*			
Algeria	Research reactor	9 April 1990	361
Albania	All nuclear material and facilities	25 March 1988	359
Argentina	Atucha Power Reactor Facility	3 October 1972	168
	Nuclear material	23 October 1973	202
	Embalse Power Reactor Facility	6 December 1974	224
	Equipment and nuclear material	22 July 1977	250
	Nuclear material, material, equipment and facilities	22 July 1977	251
	Atucha II Nuclear Power Plant	15 July 1981	294
	Heavy water plant	14 October 1981	296
	Heavy water	14 October 1981	297
	Nuclear material	8 July 1982	303

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Chile	Nuclear material	31 December 1974	256
	Nuclear material	22 September 1982	304
	Nuclear material	18 September 1987	350
Cuba	Nuclear research reactor and fuel therefor	25 September 1980	298
	Nuclear power plant and nuclear material	5 May 1980	281
	Zero-power nuclear reactor and fuel therefor	7 October 1983	311
Democratic People's Republic of Korea	Research reactor and nuclear material for this reactor	20 July 1977	252
India	Nuclear material, material and facilities	17 November 1977	260
	Nuclear power station	27 September 1988	360
	Nuclear material	11 October 1989	374
Pakistan	Nuclear material	2 March 1977	248
	Miniature neutron source reactor	10 September 1991	393
Spain	Nuclear material[d]	18 June 1975	221
	Vandellos Nuclear Power Plant[d]	11 May 1981	292
	Specified nuclear facilities[d]	11 May 1981	291*
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor	12 June 1981	293
(c) *Agreements concluded with nuclear-weapon States on the basis of voluntary offers*			
China	Nuclear material in facilities selected from list of facilities provided by China	18 September 1989	369
France	Nuclear material in facilities submitted to safeguards	12 September 1981	290
Union of Soviet Socialist Republics	Nuclear material in facilities selected from list of facilities provided by the USSR	10 June 1985	327
United Kingdom	Nuclear material in facilities designated by the Agency	14 August 1978	263
United States of America	Nuclear material in facilities designated by the Agency	9 December 1980	288
(d) *Other agreements*			
Argentina/Brazil		Signed: 13 December 1991	
Argentina/United States of America		25 July 1969	130
Austria[d]/United States of America		24 January 1970	152
Brazil/Germany[d]		26 February 1976	237
Brazil/United States of America		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada[d]		30 September 1971	211
India/United States of America		27 January 1971	154
Iran, Islamic Republic of[d]/ United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan[d]/Canada[d]		20 June 1966	85
Japan[d]/France		22 September 1972	171

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* Amended in 1985 to cover specified nuclear facilities. The amendment entered into force on 8 November 1985 (INFCIRC/291/Mod.1/Corr.1).

Table (cont.)

Party(ies)[a]	Subject	Entry into force	INFCIRC
Japan/United Kingdom		15 October 1968	125
Korea, Republic of/ United States of America		5 January 1968	111
Korea, Republic of[d]/France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines[d]/United States of America		19 July 1968	120
Portugal[d]/United States of America[e]		19 July 1969	131
South Africa/United States of America		26 July 1967	98
South Africa/France		5 January 1977	244
Spain/Germany[d]		29 September 1982	305
Spain/United States of America		9 December 1966	92
Spain/Canada[d]		10 February 1977	247
Sweden[d]/United States of America		1 March 1972	165
Switzerland[d]/United States of America[e]		28 February 1972	161
Turkey[d]/United States of America[e]		5 June 1969	123
Venezuela[d]/United States of America[e]		27 March 1968	122

(e) The Agency also applies safeguards under two agreements (INFCIRC/133 and INFCIRC/158) to the nuclear facilities in Taiwan, China. Pursuant to the decision adopted by the Board of Governors on 9 December 1971 that the Government of the People's Republic of China is the only government which has the right to represent China in the Agency, the relations between the Agency and the authorities in Taiwan are non-governmental. The agreements are implemented by the Agency on that basis.

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[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers.

[b] Agency safeguards are being applied to the items required to be safeguarded under this (these) project agreement(s) pursuant to an agreement in connection with NPT covering the State indicated.

[c] The requirement for the application of safeguards under this agreement is satisfied by the application of safeguards pursuant to the agreement of 12 June 1981 (INFCIRC/293).

[d] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with NPT.

[e] Application of Agency safeguards under this agreement has been suspended in the United States of America in order to comply with a provision of INFCIRC/288.

Safeguards operations

Verification

In carrying out its verification activities, the Agency found a number of discrepancies and anomalies. These were all subject to thorough investigation and follow-up.

Specific activities implemented during the year aimed at improving the efficiency and effectiveness of verification activities included the following:

- In accordance with the requirements of the safeguards criteria for 1991-1995, new inspection schemes, based on the zone approach, were developed and implemented in two States for natural and LEU fuel cycle facilities and for certain facilities handling direct-use material.
- The computerized inspection field support system (IFSS) was introduced into use at three additional facilities, thereby improving the inspection data processing capability in the field.
- The remote link established with the Toronto Regional Office was enhanced, enabling the secure transfer of inspection data to Headquarters at considerably reduced costs.
- The first routine inspection took place at a new commercial size enrichment plant in one State.
- The safeguards approach for LWRs using MOX fuel was further improved, resulting in reduced inspection effort thanks to the increased use of containment and surveillance (C/S) measures.

After discussion with a number of States, more advanced safeguards equipment and techniques were introduced in a number of facilities:

- Progress continued to be made in the programme for the replacement of photographic optical surveillance units, with the installation of 72 closed circuit television modular integrated video systems (MIVS) in 41 facilities.
- A set of fuel monitors was installed and tested at an experimental fast breeder reactor (FBR) and at a prototype FBR in one State to monitor the flow of nuclear material in and out of the difficult-to-access core of the reactor.
- Dual C/S systems were developed and installed at facilities having difficult-to-access spent fuel storage in four States. Dual C/S systems were also installed at storage facilities in two States in order to reduce the inspection effort needed for reverification.
- A near-real-time accountancy system was introduced at a major MOX fuel fabrication plant, and acceptance tests were completed for the advanced C/S systems installed at the plant.
- Non-destructive assay instruments were introduced for automatically verifying nuclear material in the storage canisters at a plutonium conversion facility. In addition, a system for verifying nuclear material held up in the blender glovebox was installed.
- An authentication controller for a C/S system was installed at a fast critical assembly in one State and field testing of the complete system initiated.
- Instruments for the automated counting and verification of spent fuel assemblies at a nuclear facility were installed, and acceptance tests initiated.

Safeguards inspection verification activities

	1989	1990	1991
Inspections performed	2 196	2 188	2 145
Person-days of inspection	10 132	10 381	9 442
Seals applied to nuclear material or Agency safeguards equipment detached and subsequently verified (including seals applied jointly with a group of States)	24 800	26 600	24 300
Surveillance films reviewed	3 320	3 300	3 300
Video tapes reviewed	—	700	1 065
Plutonium and uranium samples analysed	1 200	1 510	1 090
Analytical results reported	2 890	2 900	2 830

Nuclear material accountancy

Monthly summary reports were provided to States where safeguards are applied pursuant to INFCIRC/66-type agreements, detailing the accountancy reporting activity for the period, the status of the movement of material and the effect these movements have on the relevant State inventory.

Negotiation and liaison with States

South Africa acceded to the NPT in July and a safeguards agreement pursuant to NPT was concluded and entered into force in September. Negotiations were initiated for conclusion of the Subsidiary Arrangements. Three Facility Attachments were agreed upon and negotiation of the remaining Facility Attachments is proceeding. Immediately after receipt of the initial report from South Africa, ad hoc inspections were undertaken to verify the information provided. The ad hoc inspection regime is expected to be completed during the first half of 1992.

A comprehensive safeguards agreement was negotiated between the Governments of Argentina and Brazil, the ABACC and the Agency.

Committees and other regular forms of contact between the Agency and Member States, including working arrangements with facility operators, continued to make a significant contribution to the further improvement of safeguards implementation:

- Progress was made in the negotiation of Subsidiary Arrangements. One General Part to Subsidiary Arrangements (two in 1990) and 35 (5 new and 30 revised) Facility Attachments (46 in 1990) entered into force.
- Two major new Facility Attachments, one for a prototype fast breeder reactor and the other for a commercial enrichment plant, were completed and entered into force.
- A Facility Attachment was drafted and procedures for the verification of design information were established for a criticality testing facility.
- Discussions were completed with China on the selection of facilities to be inspected under China's voluntary-offer type safeguards agreement with the Agency.
- A new Facility Attachment incorporating substantial reduction in inspection effort was negotiated for an MOX fuel fabrication plant.

Approximate quantities of material subject to Agency safeguards at the end of 1991

Type of material	Quantity of material (t)			
	INFCIRC/153[a]	INFCIRC/66[b]	Nuclear-weapon States	Quantity in SQ
Nuclear material				
Plutonium[c] contained in irradiated fuel	237.6	21.4	78.0	42 128
Separated plutonium outside reactor cores	9.5	0	22.9	4 050
Recycled plutonium in fuel elements in reactor cores	2.5	0.4	0	362
HEU (equal to or greater than 20% uranium-235)	10.7	0.4	0	264
LEU (less than 20% uranium-235)	25 437	1 829	7 463	9 724
Source material[d] (natural or depleted uranium and thorium)	48 248	3 075	21 161	4 955
Total significant quantities				*61 483*
Non-nuclear material[e]				
Heavy water	0	1 433	0	72

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

[c] The quantity includes an estimated 65.0 t (8124 SQ) of plutonium in irradiated fuel, which is not yet reported to the Agency under the agreed reporting procedures (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and containment and surveillance (C/S) measures are applied).

[d] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).

[e] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

Number of facilities under safeguards or containing safeguarded material on 31 December 1991

Facility category	Number of facilities (number of installations)			
	INFCIRC/153[a]	INFCIRC/66 Rev. 2[b]	Nuclear-weapon States	Total
Power reactors	142 (171)	12 (14)	1 (1)	155 (186)
Research reactors and critical assemblies	135 (146)	22 (22)	1 (1)	158 (169)
Conversion plants	6 (7)	3 (3)	0 (0)	9 (10)
Fuel fabrication plants	34 (35)	9 (9)	1 (1)	44 (45)
Reprocessing plants	4 (4)	1 (1)	0 (0)	5 (5)
Enrichment plants	5 (5)	1 (1)	1 (1)	7 (7)
Separate storage facilities	35 (36)	6 (6)	4 (4)	45 (46)
Other facilities	49 (52)	3 (3)	0 (0)	52 (55)
Subtotals	410 (456)	57 (59)	8 (8)	475 (523)
Other locations	279 (385)	24 (28)	0 (0)	303 (413)
Non-nuclear installations	0 (0)	2 (2)	0 (0)	2 (2)
Totals	689 (841)	83 (89)	8 (8)	780 (938)

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

Facilities under Agency safeguards or containing safeguarded material on 31 December 1991

Power reactors

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Argentina	Atucha NPS	1	Lima	x
	Embalse PR	1	Embalse	—
Belgium	BR3	1	Mol	x
	DOEL-1	2	Doel	x
	DOEL-3	1	Doel	x
	DOEL-4	1	Doel	x
	Tihange-1	1	Tihange	x
	Tihange-2	1	Tihange	x
	Tihange-3	1	Tihange	x
Brazil	Angra-1	1	Angra dos Reis	x
Bulgaria	Kozloduy-I	2	Kozloduy	x
	Kozloduy-II	2	Kozloduy	x
	Kozloduy-III	2	Kozloduy	x
Canada	Bruce A	4	Tiverton	x
	Bruce B	4	Tiverton	x
	Darlington	3	Bowmanville	x
	Gentilly-2	1	Gentilly	x
	Pickering	8	Pickering	x
	Point Lepreau G.S.	1	Point Lepreau	x
Czechoslovakia	A1	1	Bohunice	x
	EDU-1	2	Dukovany	x
	EDU-2	2	Dukovany	x
	V-1	2	Bohunice	x
	V-2	2	Bohunice	x
Finland	Loviisa	2	Loviisa	x
	TVO-1	1	Olkiluoto	x
	TVO-2	1	Olkiluoto	x
Germany	AVR	1	Jülich	—
	GKW Grohnde	1	Grohnde	—
	GKN-2	1	Neckarwestheim	x
	RWE Biblis-A	1	Biblis	x
	RWE Biblis-B	1	Biblis	x
	KKW Brokdorf	1	Brokdorf	—
	KKW Brunsbüttel	1	Brunsbüttel	x
	KKW Emsland	1	Lingen	x
	KKW Grafenrheinfeld	1	Grafenrheinfeld	—
	KKW Isar	1	Ohu bei Landshut	x
	KKW Isar-2	1	Essenbach	x
	KKW Krümmel	1	Geesthacht	x
	KKW Mülheim-Kärlich	1	Mülheim-Kärlich	x
	KKW Neckarwestheim	1	Neckarwestheim	x
	KKW Obrigheim	1	Obrigheim	x
	KKW Philippsburg-1	1	Philippsburg	x
	KKW Philippsburg-2	1	Philippsburg	—

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany (cont.)	KRB II Gundremmingen B	1	Gundremmingen	x
	KRB II Gundremmingen C	1	Gundremmingen	x
	KKW Stade	1	Stade	x
	KKW Unterweser	1	Stadland	x
	KKW Würgassen	1	Würgassen	x
	KBG-KNK	1	Eggenstein-Leopoldshafen	x
	HKG-THTR 300	1	Hamm	—
	KKW Greifswald 1	2	Greifswald	—
	KKW Greifswald 2	2	Greifswald	—
	KKW Greifswald 3	1	Greifswald	—
	KKW Rheinsberg	1	Rheinsberg	—
Hungary	PAKS-I	2	Paks	x
	PAKS-II	2	Paks	x
India	RAPS	2	Rajasthan	x
	TAPS	2	Tarapur	x
Italy	ENEL-Latina	1	Borgo-Sabatino	x
	ENEL-Caorso	1	Caorso	x
	ENEL-Trino	1	Trino-Vercellese	x
Japan	Fugen	1	Tsuruga-Fukui	x
	Fukushima Dai-Ichi-1	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-2	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-3	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-4	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-5	1	Okuma-Fukushima	x
	Fukushima Dai-Ichi-6	1	Okuma-Fukushima	x
	Fukushima Dai-Ni-1	1	Naraha-Fukushima	x
	Fukushima Dai-Ni-2	1	Naraha-Fukushima	x
	Fukushima Dai-Ni-3	1	Naraha-Fukushima	x
	Fukushima Dai-Ni-4	1	Naraha-Fukushima	x
	Genkai-1	1	Kyushu	x
	Genkai-2	1	Kyushu	x
	Hamaoka-1	1	Hamaoka-cho	x
	Hamaoka-2	1	Hamaoka-cho	x
	Hamaoka-3	1	Hamaoka-cho	x
	Ikata-1	1	Nishiuwa-gun	x
	Ikata-2	1	Nishiuwa-gun	x
	Kashiwazaki-1	1	Niigata	x
	Kashiwazaki-2	1	Niigata	x
	Kashiwazaki-5	1	Niigata	x
	Mihama-1	1	Mihama-Fukui	x
	Mihama-2	1	Mihama-Fukui	x
	Mihama-3	1	Mihama-Fukui	x
	Monju	1	Tsuruga-Shi	x
	Ohi-1&2	2	Ohi-cho, Fukui-ken	x
	Ohi-3	1	Ohi-cho, Fukui-ken	x
	Onagawa-1	1	Miyaki-ken	x
	Sendai-1	1	Sendai	x
	Sendai-2	1	Sendai	x

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan (cont.)	Shimane-1	1	Kashima-cho	x
	Shimane-2	1	Kashima-cho	x
	Takahama-1	1	Takahama	x
	Takahama-2	1	Takahama	x
	Takahama-3	1	Takahama	x
	Takahama-4	1	Takahama	x
	Tokai-1	1	Tokai-Mura	x
	Tokai-2	1	Tokai-Mura	x
	Tomari-1	1	Tomari-Mura	x
	Tomari-2	1	Tomari-Mura	x
	Tsuruga-1	1	Tsuruga	x
	Tsuruga-2	1	Tsuruga	x
Korea, Republic of	Kori-1	1	Pusan	x
	Kori-2	1	Pusan	x
	Kori-3	1	Pusan	x
	Kori-4	1	Pusan	x
	Uljin-1	1	Uljin	x
	Uljin-2	1	Uljin	x
	Wolsung-1	1	Ulsan	x
	Youngwang 1	1	Pusan	x
	Youngwang 2	1	Pusan	x
Mexico	Laguna Verde 1	1	Alto Lucero	x
Netherlands	Borssele	1	Borssele	x
	Dodewaard NPP	1	Dodewaard	x
Pakistan	KANUPP	1	Karachi	x
Philippines	PNPP-1	1	Morong, Bataan	x
South Africa	Koeberg-1	1	Cape Town	x
	Koeberg-2	1	Cape Town	x
Spain	Almaraz-1	1	Almaraz	—
	Almaraz-2	1	Almaraz	—
	Asco-1	1	Asco	—
	Asco-2	1	Asco	—
	Cofrentes	1	Cofrentes	—
	José Cabrera	1	Almonazid de Zorita	—
	Santa María de Garona	1	Santa María de Garona	—
	Trillo-1	1	Trillo	—
	Vandellos 1	1	Vandellos	—
	Vandellos 2	1	Vandellos	—
Sweden	Barsebäck I	1	Malmö	x
	Barsebäck II	1	Malmö	x
	Forsmark I	1	Uppsala	x
	Forsmark II	1	Uppsala	x
	Forsmark III	1	Uppsala	x
	Oskarshamn I	1	Oskarshamn	x
	Oskarshamn II	1	Oskarshamn	x
	Oskarshamn III	1	Oskarshamn	x

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Sweden (cont.)	Ringhals I	1	Göteborg	x
	Ringhals II	1	Göteborg	x
	Ringhals III	1	Göteborg	x
	Ringhals IV	1	Göteborg	x
Switzerland	KKB-I	1	Beznau	x
	KKB-II	1	Beznau	x
	KKG	1	Gösgen-Däniken	x
	KKL	1	Leibstadt	x
	KKM	1	Mühleberg	x
Union of Soviet Socialist Republics	Novo Voronezh Unit 5	1	Novo Voronezh	x
Yugoslavia	Krško	1	Krško	x

Research reactors and critical assemblies

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Algeria	NUR Reactor	1	Wilaya de Tipaza	—
Argentina	RA-1	1	Constituyentes	x
	RA-2	1	Constituyentes	x
	RA-3	1	Ezeiza	x
	RA-4	1	Rosario	x
	RA-6	1	Bariloche	x
	RA-0	1	Córdoba	—
Australia	HIFAR	1	Lucas Heights	x
	MOATA	1	Lucas Heights	x
	CF	1	Lucas Heights	x
Austria	ASTRA	1	Seibersdorf	x
	SAR	1	Graz	x
	Triga II	1	Vienna	x
Bangladesh	Atomic Energy Research Est.	1	Ganakbari Savar Dhaka	x
Belgium	BR1-CEN	1	Mol	x
	BR2-CEN-BRO2	2	Mol	x
	CEN-Venus	1	Mol	x
	Thetis	1	Gent	x
Brazil	IEAR-1	1	São Paulo	x
	RIEN-1	1	Rio de Janeiro	x
	Triga-CDTN	1	Belo Horizonte	x
Bulgaria	IRT-2000	1	Sofia	x
Canada	McMaster	1	Hamilton	x
	NRU	1	Chalk River	x
	NRX	1	Chalk River	x
	Health&Physics	2	Chalk River	x
	Slowpoke-AECL	1	Ottawa	x
	Slowpoke-Dalhousie Univ.	1	Halifax	x
	Slowpoke-Ecole Polytechnique	1	Montreal	x
	Slowpoke-Kingston	1	Kingston	x
	Slowpoke-Saskatchewan	1	Saskatoon	x
	Slowpoke-Toronto University	1	Toronto	x
	Slowpoke-Univ. of Alberta	1	Edmonton	x
	WNRE	1	Pinawa	x
Chile	La Reina	1	Santiago	x
	Lo Aguirre	1	Santiago	x
Colombia	IAN-R1	1	Bogotá	x
Czechoslovakia	LR-O	1	Řež	x
	SR-OD	1	Vochov	x
	Univ. Training Reactor VR-1P	1	Prague	x
	VVR-S	1	Řež	x
Democratic People's Republic of Korea	Critical assembly	1	Nyonphyon	x
	IRT-DPRK	1	Nyonphyon	x
Denmark	DR-1	1	Roskilde	x
	DR-3	1	Roskilde	x
Egypt	Nuclear Research Centre	1	Inshas	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Finland	Triga II	1	Otaniemi	x
Germany	BER-2	1	Berlin	x
	FMRB	1	Braunschweig	x
	FRF-2	1	Frankfurt	x
	FRM	1	Garching	x
	GKSS-FRG1&FRG2	2	Geesthacht	x
	KFA-FRJ1	1	Jülich	x
	KFA-FRJ2	1	Jülich	x
	SUR 100	1	Bremen	x
	SUR 100	1	Eggenstein-Leopoldshafen	x
	SUR 100	1	Hannover	x
	SUR 100	1	Kiel	x
	SUR 100	1	Hamburg	x
	SUR 100	1	Ulm	x
	SUR 100	1	Stuttgart	x
	SUR 100	1	Furtwangen	x
	SUR 100	1	Darmstadt	x
	SUR 100	1	Berlin	x
	SUR 100	1	Aachen	x
	Tech. Univ. AKR	1	Dresden	—
	Tech. Hochschule ZLR	1	Zittau	—
	Triga	1	Mainz	x
	Triga	1	Hannover	x
	Triga II	1	Heidelberg	x
	ZFK RAKE&RRR	2	Rossendorf	—
	ZFK research reactor	1	Rossendorf	—
Greece	GRR-1	1	Attiki	x
Hungary	Training reactor	1	Budapest	x
	WWR-S M	1	Budapest	x
	ZR-6	1	Budapest	x
Indonesia	Gama	1	Yogyakarta	x
	MPR-30	1	Serpong	x
	PPTN	1	Bandung	x
Iran, Islamic Republic of	TSPRR	1	Teheran	x
Iraq	IRT-5000	1	Baghdad Tuwaitha	x
	Tamuz-2	1	Baghdad Tuwaitha	x
Israel	IRR-1	1	Soreq	x
Italy	AGN-201	1	Palermo	x
	CESNEF-L54	1	Milan	x
	RB-3	1	Montecuccolino	x
	RTS-1	1	San Piero a Grado	x
	TAPIRO	1	Santa Maria di Galeria	x
	Triga-RC1	1	Santa Maria di Galeria	x
	Triga-2	1	Pavia	x
Jamaica	Centre for Nuclear Sciences	1	Kingston	x

Research reactors and critical assemblies (cont.)

State*	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan	DCA	1	Oarai-Machi	x
	FCA	1	Tokai-Mura	x
	HTR	1	Kawasaki-shi	x
	JMTR	1	Oarai-Machi	x
	JMTR-CA	1	Oarai-Machi	x
	JOYO	1	Oarai-Machi	x
	JRR-2	1	Tokai-Mura	x
	JRR-3	1	Tokai-Mura	x
	JRR-4	1	Tokai-Mura	x
	Kinki University R.R.	1	Kowake	x
	KUCA	3	Kumatori-cho	x
	KUR	1	Kumatori-cho	x
	Musashi College R.R.	1	Kawasaki	x
	N.S. Mutsu	1	Minato-Machi	x
	NCA	1	Kawasaki-ku	x
	NSRR	1	Tokai-Mura	x
	Rikkyo University R.R.	1	Nagasaka	x
	TCA	1	Tokai-Mura	x
	TODAI	1	Tokai-Mura	x
	TTR	1	Kawasaki-shi	x
	VHTRC	1	Tokai-Mura	x
Korea, Republic of	Triga II&III	2	Seoul	x
	Kyung-Hee Univ.	1	Seoul	x
Libyan Arab Jamahiriya	IRT-Tajura	1	Tajura	x
Malaysia	Puspati	1	Bangi, Selangor	x
Mexico	Triga III	1	Ocoyoacac	x
	SUR 100	1	Mexico City	x
Netherlands	HOR	1	Delft	x
	HFR	1	Petten	x
	LFR	1	Petten	x
Norway	HBWR-Halden	1	Halden	x
	JEEP-II	1	Kjeller	x
Pakistan	PARR-1	1	Rawalpindi	x
Peru	Centro nucl. de investigaciones	1	San Borja	x
	RP-O	1	Lima	x
Philippines	PRR-1	1	Diliman, Quezon City	x
Poland	Agata&Anna	2	Świerk	x
	Ewa	1	Świerk	x
	Maria	1	Świerk	x
Portugal	RPI	1	Sacavem	x
Romania	Triga II	1	Piteşti Colibaşi	x
	VVR-S	2	Magurele	x
South Africa	SAFARI-1	1	Pelindaba	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Spain	ARBI	1	Bilbao	—
	ARGOS	1	Barcelona	—
	JEN-1 and JEN-2	1	Madrid	—
Sweden	R2&R2-O	2	Studsvik	x
Switzerland	AGN 211P	1	Basel	x
	Crocus	1	Lausanne	x
	Proteus	1	Würenlingen	x
	Saphir	1	Würenlingen	x
Thailand	TRR-1	1	Bangkok	x
Turkey	TR-1	1	Istanbul	x
	ITU-TRR	1	Istanbul	x
Union of Soviet Socialist Republics	IR-8 Research Reactor	1	Moscow	x
Uruguay	Lockheed	1	Montevideo	x
Venezuela	RV-I	1	Altos de Pipe	x
Viet Nam	Da Lat Research Reactor	1	Da Lat	x
Yugoslavia	RA-RB	2	Vinča	x
	Triga II	1	Ljubljana	x
Zaire	Triga-Zaire	1	Kinshasa	x

Conversion plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	UO_2 Conversion Plant	Córdoba	—
	Uranium Powders Fabrication Plant	Constituyentes	—
Canada	CAMECO	Port Hope	x
Japan	Japan Nuclear Fuel Conversion Co. Ltd.	Tokai-Mura	x
	Ningyo R & D	Ningyo	x
	PCDF	Tokai-Mura	x
Romania	UO_2 powder fab. plant	Feldioara	—
South Africa	Conversion plant	Pelindaba	—

Fuel fabrication plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Atucha Fuel Fabrication Plant	Ezeiza	—
	Fuel Fabrication Plant (CANDU)	Ezeiza	—
	Pilot Fuel Fabrication Plant (HEU)	Constituyentes	x
	Research Reactor Fuel Fab. Plant	Constituyentes	—
Belgium	BN-MOX	Dessel	x
	FBFC	Dessel	x
	FBFC MOX Assembling Facility	Dessel	—
Brazil	Fuel Fabrication Plant Resende	Resende	x
Canada	CRNL Fuel Fabrication	Chalk River	x
	Fuel fabrication facility	Chalk River	—
	GEC	Peterborough	x
	GEC	Toronto	x
	Zircatec P.I. Ltd	Port Hope	x
Denmark	Metallurgy	Roskilde	x
Germany	Exxon	Lingen	x
	NUKEM	Wolfgang	x
	Siemens Uran (two units)	Hanau	x
	Siemens MOX	Hanau	x
India	Ceramic fuel fab. assembly area	Hyderabad	x
	EFFP-NFC	Hyderabad	x
Indonesia	Experimental Fuel Element Installation (IEBE)	Serpong	x
	Research Reactor Fuel Element Production Installation (IPEBRR)	Serpong	x
Iraq	ERLFF	Baghdad Tuwaitha	x
Italy	Fabnuc	Bosco Marengo	x
	IFEC	Saluggia	x
Japan	JNF	Yokosuka	x
	MNF	Tokai-Mura	x
	NFI (Kumatori-1)	Kumatori, Osaka	x
	NFI (Kumatori-2)	Kumatori, Osaka	x
	NFI (Tokai) Fuel Fabrication	Tokai-Mura	x
	PFPF	Tokai-Mura	x
	PPFF	Tokai-Mura	x
Korea, Republic of	CFFP	Daejeon	x
	LEU Fuel Fabrication	Daejeon	x
Mexico	Fuel Fabrication Plant	Ocoayacac	—
Romania	Romfuel	Piteşti Colibaşi	x
South Africa	MTR fuel fabrication	Pelindaba	—
	PWR fuel fabrication	Pelindaba	—
Spain	CIEMAT Planta Metall.	Madrid	—
	ENUSA Fuel Fabrication Plant	Juzbado	—
Sweden	ASEA-ATOM	Västeras	x
United States of America	Babcock & Wilcox Co.	Lynchburg, VA	x

Chemical reprocessing plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Germany	WAK	Eggenstein-Leopoldshafen	x
India	PREFRE	Tarapur	x
Italy	EUREX	Saluggia	x
	ITREC-Trisaia	Rotondella	x
Japan	Tokai Reprocessing Plant	Tokai-Mura	x

Enrichment plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Brazil	Sep. Noz. Enrichment Plant	Resende	x
Germany	URENCO Deutschland, UTA-1	Gronau	x
Japan	Uranium Enrichment Plant	Ningyo	x
	Rokkosho-Mura	Rokkosho-Mura	x
Netherlands	URENCO Nederland	Almelo	x
South Africa	Semi-Commercial Enrichment Plant	Pelindaba	—
United Kingdom	BNFL Centrifuge plant and associated storage	Capenhurst	x

Separate storage facilities

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Central store	Ezeiza	—
	Storage of depleted hexafluoride	Bariloche	—
	Storage of zircaloy tubes	Ezeiza	—
	Storage of 20% enriched uranium	Cac	—
Belgium	Belgoprocess	Mol	x
	BN UF_6 store	Dessel	x
Bulgaria	AFRS	Kozloduy	—
Canada	CRNL	Chalk River	x
	CRNL spent fuel dry store	Chalk River	—
	Douglas Point	Tiverton	x
	Gentilly-1	Gentilly	x
	Long term storage at CRNL	Chalk River	—
Chile	Lab. experimental de conversión	Santiago	x
Czechoslovakia	AFRS	Bohunice	x
Denmark	Risø Store	Roskilde	x
	Risø Waste	Roskilde	—
Finland	Long term storage for TVO	Olkilouto	—
France	COGEMA UP2 spent fuel storage ponds	La Hague	x
Germany	Bundeslager	Wolfgang	—
	Exxon Nuclear UF6 Lageranlage	Lingen	x
	KFA Jülich Lager (AVR Kugeln)	Jülich	x
	KFK-FR-2	Eggenstein-Leopoldshafen	x
	Lageranlage	Kalkar	—
	LSG Offset-Lager	Hanau	—
	Nuclear Cargo & Services	Hanau	—
	Urananlage	Birkenfeld	x
	TNH GesmbH	Landsbergen-Leese	—
	VEB Greifswald	Greifswald	—
Iraq	Separate storage facility	Baghdad Tuwaitha	x
Italy	Avogadro	Saluggia	x
	Deposito Prodotti Uraniferi	Bosco Marengo	x
	Essor Nuclear Plant	Ispra	—
	Essor Storage Pond	Ispra	—
	Ispra Central Storage	Ispra	x
	Joint Research Centre	Ispra	—
Japan	KUFFS	Kyoto	x
Luxembourg	International Metals S.A.	Luxembourg-Dommeldange	x
Pakistan	Storage at Government depot	Karachi Malir	x
Portugal	Instalação de Armazenagem	Sacavem	x
South Africa	Waste Storage	Pelindaba	—
Sweden	Central long term storage	Oskarshamn	x
Switzerland	Diorit Storage	Würenlingen	x
United Kingdom	Oxide Fuel Storage Pond	Sellafield	x
	Sellafield Pu-storage	Sellafield	x
	Special nuclear material store 9	Sellafield	x

Other facilities

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Lab. de Calificación	Constituyentes	—
	Lab. triple altura	Ezeiza	—
Australia	Research Laboratory	Lucas Heights	x
Belgium	BCMN	Geel	x
	CEN-Labo	Mol	x
	CEN-Waste	Mol	—
	I.R.E.	Fleurus	x
	Pu laboratory	Mol	x
Czechoslovakia	Nuclear Fuel Inst. (UJP)	Zbraslav	x
	Research Laboratories	Řež	x
Denmark	Hotcell Plant	Roskilde	x
Germany	Deutsches Elektronen-Synchrotron	Hamburg	—
	Institut für Kernphysik-1	Eggenstein-Leopoldshafen	x
	KFA-heisse Zellen	Jülich	x
	KFK-heisse Zellen	Eggenstein-Leopoldshafen	x
	KFK/IHCH	Eggenstein-Leopoldshafen	x
	KFK/IMF3	Eggenstein-Leopoldshafen	x
	KWU-heisse Zellen	Karlstein	x
	Lab. d. KFA Jülich	Jülich	x
	Transuran	Eggenstein-Leopoldshafen	x
	Urantechnikum	Rossendorf	—
	ZFK Amor 1 & 2	Rossendorf	—
Italy	CNEN-LAB. PU.	Santa Maria di Galeria	x
	CNEN-LAB. TEC.	Santa Maria di Galeria	x
Japan	JAERI-Oarai R&D	Oarai-Machi	x
	JAERI-Tokai R&D	Tokai-Mura	x
	Kyoto Univ. Kumatori	Osaka	x
	NDC Fuel Hot Lab.	Tokai-Mura	x
	NDC fuel laboratories	Tokai-Mura	x
	NERL, University of Tokyo	Tokai-Mura	x
	NFD	Oarai-Machi	x
	NFI Tokai II	Tokai-Mura	x
	NRF Neutron Radiation Facility	Tsukuba	x
	PNC FMF	Oarai-Machi	x
	PNC IRAF	Oarai-Machi	x
	PNC-Oarai R&D	Oarai-Machi	x
	PNC-Tokai R&D	Tokai-Mura	x
	Uranium material laboratory	Oarai-Machi	x
Korea, Republic of	PIEF	Daejeon	x
Netherlands	ECN & JRC	Petten	x
	Kema Lab.	Arnhem	x
Norway	Research laboratories	Kjeller	x

Other facilities (cont.)

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Poland	Institute for nuclear chemistry and engineering	Warsaw	—
	Institute of Nuclear Research	Świerk	x
South Africa	Decommissioned pilot enrichment plant	Pelindaba	—
	Decontamination and waste	Pelindaba	—
	Hot Cell Complex	Pelindaba	x
	NU and DU processing plant	Pelindaba	—
Spain	CIEMAT Lab-Pu	Madrid	—
Sweden	Central storage fresh fuel	Studsvik	x
Switzerland	Fed. Inst. of Reactor Research	Würenlingen	x

Non-nuclear installations

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Heavy water plant	Arroyito	—
	Heavy water storage	Buenos Aires	x

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

Note: The Agency was also applying safeguards in Taiwan, China, at six power reactors, six research reactors/critical assemblies, one uranium pilot conversion plant, two fuel fabrication plants and one research and development facility.

Safeguards support and development

Safeguards systems for:
— fuel fabrication plants

At a large MOX plant currently under construction, a safeguards approach for the fuel processing area has been concluded. Selections have been made and procurement specifications approved for safeguards equipment to be installed at the plant. Contract negotiations to enable the plant operator to serve as general contractor and to begin procurement actions were concluded. Development of software essential to the completion of the project has taken place under a Member State support programme.

— reprocessing plants

Work continued on the development of safeguards approaches for new, large scale reprocessing plants. Both generic and facility specific issues relating to spent fuel storage, continuous dissolution head-end systems, plutonium conversion and plutonium product storage were addressed. A project team was established for the development of a safeguards system for a large scale commercial reprocessing plant and the initial project plan prepared.

— heavy water production plants

Instrumentation for safeguards at a heavy water production plant kept pace with the plant construction progress. An analytical method, applicable to on-line automation, was shown to be feasible. An engineering package for the procurement of outstanding measurement instruments was completed. The project to apply safeguards to the plant was suspended and further decisions will be taken in light of the new comprehensive safeguards agreement concluded with Argentina, Brazil and the ABACC.

— multi-unit nuclear power stations

Progress was made in the implementation of the safeguards approach at a multi-unit on-load reactor (OLR) nuclear power station. The core discharge monitor (CDM) was commissioned in two reactor units at the station and routinely detected pairs of irradiated fuel bundles discharged from the reactor core under a range of operational conditions. Installation of the CDM was started in a third reactor unit. The CDM has been authorized for inspection use as a vault radiation monitor and was used in conjunction with short notice random inspections to safeguard the core fuel. Final authorization of the remaining CDM functions is expected in the first half of 1992.

As a measure to improve safeguards goal attainment on core fuel in the near term at other multi-unit OLRs, alternative safeguards approaches are being investigated. A detailed study is in process on a safeguards approach which makes use of the unique identification number inscribed on each CANDU fuel bundle.

System studies

Work continued on the implementation and further development of a new safeguards approach for OLRs under construction. Interim safeguards measures are under development for the reactor cores of the CANDU-type multi-unit OLRs already operating.

The Agency continued to participate in the multinational meetings under the auspices of the LASCAR project (Large Scale Reprocessing Plant Safeguards). Following earlier studies on spent fuel storage and head-end dissolution, discussions were completed on the main process area and product storage systems. Preparation of the final reports is under way. The LASCAR studies will provide a useful compendium of technical alternatives for safeguarding large reprocessing plants.

System studies (cont.)

A group of consultants discussed the application of safeguards to multiple facility fuel cycles and recommended that the Agency continue its testing and implementation of the zone approach. The consultants also recommended that consideration be given to extending the principle of randomization to the selection of facilities for inspection, with adequate field testing of such new applications before routine use.

In consultation with Member States, the Agency continued a programme to develop safeguards requirements and methodologies for geological repositories and to formulate a safeguards policy well before such facilities start operation. A group of consultants discussed safeguards measures applicable to spent fuel placed in geological storage, providing a basis for further development of a safeguards approach and technical means for its implementation.

In support of SAGSI consideration of the definition of irradiated direct use material for the purposes of safeguards, a study of the radiation levels of power and research reactor spent fuel was initiated.

The 1993–1994 Safeguards Research and Development (R&D) Programme was finalized. The Programme takes into account SAGSI recommendations and presents the Department's R&D needs in a systematic and problem oriented manner, assigning priorities to each problem in order to distribute resources in a more efficient way.

Instrument development

A safeguards topical meeting to discuss the development of an integrated surveillance package was held in November with representatives from Member State support programmes. The meeting reviewed the need for integration and standardization of safeguards instrumentation.

Under the programme for the replacement of optical surveillance units, reliability tests were conducted on the compact surveillance and monitoring system (COSMOS).

The development and testing of the multicamera optical surveillance system (MOS) was completed. The system (which includes a multichannel authentication device tamper resistant TV link (TRTL) for video authentication of multicamera surveillance systems) was authorized for inspection use. A vulnerability study of the tamper resistant TV link was successfully completed.

A PC based remote surveillance system capable of transmitting data and video images over the telephone system was developed and successfully tested.

Upgrading of the multi-unit TV surveillance systems (MUX) to improve the picture quality and to speed up the tape review activities was completed.

To help reduce the time required to review tapes recorded on the different surveillance systems, an optical surveillance data reduction programme was established, and evaluations carried out on three different image processing systems for optical surveillance review stations. User requirements for the generic review stations were formulated. A workshop was held to discuss the feasibility of developing a generic review station based on the finalized user requirements. The proposal was deemed to be technically feasible and two potential solutions were discussed in detail.

Instrument development (cont.)

A new partial defect test method for the verification of fresh LWR MOX fuel assemblies stored under water was developed. A field test of the equipment was successfully carried out in co-operation with a group of States.

A new method for verifying stacks of modules filled with spent CANDU fuel bundles stored in dry long term storage canisters was developed. This uses a miniature cadmium telluride detection probe inserted into a measurement channel in the storage cask. A field test of the equipment was carried out successfully.

Tests of a new Cobra seal with decreased vulnerability were undertaken. Specifications for the development of an in situ readable ultrasonic seal system were established, and preliminary design work initiated.

Nine more standard measurement procedures were finalized with the assistance of Member State support programmes and seven instrument instruction manuals issued for the use of inspectors.

Instrument, equipment and analytical services

Maintenance and calibration services were provided to the NDA, video and other surveillance equipment used by the inspectorate, including preventive maintenance and servicing of equipment installed in nuclear facilities. Calibrations on a total of 136 instruments and repair of 357 pieces of equipment were performed.

Work started on the development of a computerized equipment management system to control the procurement, inventory, distribution, performance and maintenance of safeguards equipment, which now has a value of over $25 million.

The median times required to complete verification by off-site destructive analysis (DA) were 56 days for uranium, 55 days for plutonium and 83 days for spent fuel samples.

The Safeguards Analytical Laboratory (SAL) and the Network of Analytical Laboratories (NWAL) performed 4075 measurements for calibration and quality control of NDA techniques, for certification of secondary reference samples, for maintenance and improvement of off-site DA and for testing procedures for on-site DA. In addition, 3352 measurements were performed by SAL and NWAL for the routine quality control of the analyses of inspection samples. SAL also assisted in the measurement of samples taken in Iraq during inspections carried out pursuant to Resolution 687 (1991), and performed about 320 such measurements.

With the assistance of Member State support programmes and the NWAL, the following major development activities were pursued:

- Optimization of an automatic potentiometric titration method for routine analyses of milligram size plutonium inspection samples.
- Set-up and testing of a new automated uranium titrator.
- Investigations to improve the precision and accuracy of isotopic analyses and isotopic dilution mass spectrometry to $<0.1\%$ relative.
- Verification of ^{237}Np determination by an isotopic dilution gamma spectrometric method using a computer program.
- Development of a procedure for the decontamination of liquid alpha bearing discards produced at SAL.

Technical support for safeguards activities

	1989	1990	1991
Twin and triple photo units in use	278	261	225
Photo cameras repaired and tested	288	227	134
Twin photo unit failures related to equipment	0.5%	0.8%	0.5%
Video camera systems (including MIVS) in use	66	109	172
— MIVS in use	—	43	115
— Mean time between failure	—	—	30 months
— MIVS failures related to equipment	—	—	31
Metallic cap seals issued	14 618	15 300	17 107
Metallic cap seals verified	13 543	14 851	14 040
Shipments of equipment and supplies	354	320	366
Hand carried transport of equipment and supplies	412	425	394
Shipments of nuclear material and chemicals to facilities	124	141	118
Procurement actions	1 240	1 337	1 205
Shipment of inspection samples to SAL	176	210	201

Standardization and quality assurance activities

Standardization activities increased in 1991 as a result of the implementation of the revised safeguards criteria, in particular resulting in substantial revisions to the Safeguards Manual and procedures.

The quality control program for the computerized inspection reporting system was modified to make it consistent with the safeguards criteria for 1991–1995. A total of 2230 inspection reports (2286 in 1990) and 2506 inspection statements (2485 in 1990) were reviewed and computerized quality control checks applied.

Reports on the quality and timeliness of inspection documentation packages were made routinely. The average time required between an inspection and the dispatch of the results to the State in which the inspection was performed increased to 61 days (52 in 1990 and 50 in 1989). This was mainly due to the adjustments necessary in implementing the revised criteria.

The testing of the seals verification activity continued. Within this programme, deliberately altered seals were submitted as a blind test of the Headquarters' verification capability. Also, a number of inspection reports were randomly selected and in-depth reviews of the documentation on surveillance application were performed.

Statistical analysis

Major revisions in inspection sample size and material balance methodologies were implemented in 1991. During 1991, 433 routine data evaluation reports were prepared. The total comprises material balance evaluations (122), operator–inspector pair evaluations (206) and verification performance history analyses (105).

Data processing

Under the auspices of a Member State support programme, a computerized system for generating nuclear material accounting reports for power reactors was developed and provided to most States where safeguards are applied pursuant to INFCIRC/153-type agreements for their consideration and use.

Data processing (cont.)

A new mainframe computer with enhanced disk storage devices was installed. Work continued on installing cabling for local area network (LAN) stations.

Prototype applications were developed using new client-server database technology, combined with graphical user interfaces on the LAN. The choice of a new data processing environment, tools and platform was confirmed by an in-depth study.

Training

Two introductory courses on Agency safeguards were conducted for new inspectors. Twenty-six other training courses for Professional and General Service staff as well as individual training were organized at Headquarters and in Member States. Substantial support in the organization and conduct of training courses continued to be provided by Member State support programmes.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on implementation of State Systems for Accounting and Control of Nuclear Materials	Japan	19	3 weeks
International course on implementation of State Systems for Accounting and Control of Nuclear Materials	USA	33	3 weeks
Seminar on the practical implementation of Agency safeguards at the facility level	South Africa	42	4 days

Safeguards management

Strengthening the safeguards system

The Agency initiated studies of ways in which the safeguards system could be strengthened. The General Conference adopted Resolution GC(XXXV)/RES/559 calling on the Board of Governors and the Director General to continue their efforts to maintain and strengthen the effectiveness and efficiency of the safeguards system in conformity with the Statute. Papers were prepared on the issues of special inspections, safeguards in nuclear-weapon States, safeguards considerations in the design of facilities, universal reporting of exports of nuclear material and significant quantities, and the Board of Governors began its consideration of some of these issues.

SAGSI

Two regular meetings and two working group meetings were held by the Standing Advisory Group on Safeguards Implementation (SAGSI). As its major activity SAGSI continued its critical study of new and improved safeguards procedures. The principal areas addressed included the categorization of nuclear material, applications of randomization and advances in technology. SAGSI discussed and made recommendations concerning the safeguards R&D programme for 1993-1994, and also reviewed the experience gained since the implementation of the revised safeguards criteria at the beginning of 1991.

Introduction of revised safeguards criteria and effectiveness evaluation

Revised safeguards criteria were introduced in 1991 to be used for implementation and evaluation purposes in the period 1991-1995. Measures were taken, including modification of the internal reporting system and the development of new evaluation procedures, algorithms and software to permit evaluation of inspection goal attainment for 1991 according to the new criteria. After technical review, facility specific safeguards procedures required by these criteria were approved for implementation. Introduction of the revised safeguards criteria has led to increased usage of dual containment and surveillance (C/S) systems and zone approaches.

A number of workshops were held with Member States to discuss the impact of the revised criteria.

The evaluation of inspection goal attainment for 1990 was made according to the safeguards criteria previously communicated to Member States. The results were reported to the Board of Governors in the Safeguards Implementation Report (SIR).

Support programmes

A meeting of Member State support programme co-ordinators was convened in April to review the experience gained in the implementation of the support programme management and administrative procedures. The meeting was attended by about 40 representatives from 14 national support programmes; representatives from two additional States attended as observers.

Additional support provided by States

States and organizations representing groups of States having formal support programmes (indicating the year initiated)		States having R&D contracts and test programmes
Australia	1989	Argentina
Belgium*	1982	Austria
Canada	1977	Bulgaria
European Atomic Energy Community	1981	Czechoslovakia
Finland	1988	Hungary
France	1983	Latvia
Germany	1978	Pakistan
Hungary	1991	Yugoslavia
Indonesia*	1989	
Japan	1981	
Sweden	1987	
USSR	1982	
United Kingdom	1980	
United States of America	1976	

* Presently inactive

Direction and support

Administration

Regular Budget

On the basis of an exchange rate of 12.70 Austrian Schillings to one United States dollar, the General Conference appropriated an amount of $178 878 000 for the Regular Budget. This amount had to be adjusted in accordance with the adjustment formula presented in the attachment to Resolution GC(XXXIV)/RES/534 in order to take into account the exchange rate actually experienced during the year—11.65 Austrian Schillings to one United States dollar.

The Regular Budget for 1991, at an exchange rate of 11.65 Austrian Schillings to one United States dollar, amounted to $192 393 000, of which $177 514 000 was to be financed from contributions by Member States on the basis of the 1991 scale of assessment, an amount of $6 700 000 was to be funded from the 1988 cash surplus, $4 533 000 from income from reimbursable work for others and $3 646 000 from other miscellaneous income. The amount of $6 700 000 represented a special appropriation for the acquisition of major equipment (safeguards equipment and computer mainframe equipment).

Expenditures

The actual expenditures in 1991 amounted to $181 770 977. In addition, the authority to spend an amount of $7 796 936 was reserved for deferred programme activities to be carried out in 1992 if arrears of contributions would be received in time. Together with the actual expenditures this resulted in an unencumbered balance of $2 825 087. As one large contributor failed to pay its contribution in 1991, the financial situation deteriorated for the first time to a point where a large number of activities could not be carried out but had to be deferred to the subsequent year as provided for in such circumstances in the Agency's Financial Regulations.

Voluntary contributions

The target for voluntary contributions to the Technical Assistance and Co-operation Fund in 1991 was established at $49 million. At the end of the year, $38 423 983 had been pledged by Member States in support of the technical assistance programme.

Extrabudgetary contributions

A total of $26 740 851 was offered in extrabudgetary contributions by Member States, the United Nations and other international organizations during 1991. Of this amount, $10 735 367 was for technical assistance projects, $4 387 762 was in support of safeguards, $3 201 914 for projects in the field of food and agriculture, $1 314 185 for nuclear safety, $3 526 950 for the implementation of United Nations Security Council Resolution 687 on Iraq and $537 269 for Regional Co-operation Agreements (RCA). The remaining $3 037 404 was in support of various other projects implemented by the Agency.

In addition, extrabudgetary resources amounting to $18 240 429 (supplemented by the Agency's contribution of $1 379 911) were donated for the ICTP and $1 475 912 (supplemented by the Agency's contribution of $2 072 187) for the IAEA-MEL.

Personnel

At the end of 1991 the number of members of the Secretariat was 2193 — 835 in the Professional and higher categories, 1220 in the General Service category and 138 in the Maintenance and Operatives Service category. These figures represent: members of the Secretariat occupying manning table posts (1623), and staff charged to manning table posts or funded from the Regular Budget (107) or to the temporary assistance fund (119); officials serving on a reimbursement basis (269); Commissary and Housing staff (75).

Among the 612 staff members in posts subject to geographical distribution, 77 nationalities were represented.

Conditions of employment

In the context of the medium term plan a preliminary analysis was made of the problems caused by the Professional salary system (see GOV/INF/608 and GOV/INF/620, paragraph 40.2). A proposal was worked out jointly with other organizations belonging to the United Nations common system for a new approach to Professional remuneration.

A comprehensive survey of the best prevailing local conditions of employment of General Service staff was carried out by the ICSC in Vienna. The survey resulted in salary increases for the lower grades and a freezing of the scales for the higher grades. A proposal was also made to incorporate the salary scales for the Maintenance and Operatives Service category into the General Service scale.

Recruitment

Progress in recruiting Professional staff in posts subject to geographical distribution was closely monitored to ensure that in compliance with General Conference Resolution GC(XXV)/RES/386 the staff chosen from developing countries be increased. At the end of 1991 such staff accounted for 28.7% of the total staff. Likewise, special attention was paid to improving the number of women on the staff in Professional posts. By the end of 1991 the percentage of women in Professional posts amounted to 14.4%.

Computerization of the personnel/payroll system

The second phase of the development of a new personnel/payroll system, which was partly financed by Germany, was completed.

Regional training course on nuclear law and safety reguations

A training course for lawyers and administrators from Member States of the African region was organized in Nairobi, Kenya. The main objectives were: to brief participants on current developments in the field of international and national nuclear law, with special reference to activities where domestic legislative action is required, and on international co-operation in nuclear matters; and to assist countries of the region in establishing a legislative framework for radiation protection and nuclear safety. The course was attended by 20 participants from 18 countries.

Denuclearization of Africa

The Agency was represented by a legal officer at a meeting of experts held in Addis Ababa, Ethiopia, in May to examine the modalities and elements for the preparation and implementation of a convention or treaty on the denuclearization of Africa. The meeting was convened by the Department for Disarmament Affairs of the United Nations in co-operation with the OAU pursuant to General Assembly Resolution 45/56A of 1990.

Russian Federation

On 26 December 1991, the Director General received a Note from the Minister of Foreign Affairs of the Russian Federation informing him, inter alia, that the membership of the Union of Soviet Socialist Republics "in all conventions, agreements and other international legal instruments, which were concluded

Russian Federation (cont.)

within its framework or under its aegis is continued by the Russian Federation (RF) and in this connection in the IAEA the name: 'The Russian Federation' should be used in the place of the name 'The Union of Soviet Socialist Republics'."

Status of Conventions and Agreements

By the end of 1991, there were no additional acceptances of the Agreement on the Privileges and Immunities of the IAEA (reproduced in document INFCIRC/9/Rev. 1). The number of Member States who have accepted the Agreement remains 61.

The status of the Vienna Convention on Civil Liability for Nuclear Damage, which entered into force on 12 November 1977, remained unchanged, with 14 States Party.

During 1991, 12 States and EURATOM expressed consent to be bound by the Convention on the Physical Protection of Nuclear Material (reproduced in document INFCIRC/274/Rev. 1), which entered into force on 8 February 1987. There were 40 Parties by the end of the year.

The Convention on Early Notification of a Nuclear Accident (reproduced in document INFCIRC/335), which entered into force on 27 October 1986, was ratified or accepted by six States and acceded to by one State during 1991. By the end of the year there were 61 Parties.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in document INFCIRC/336), which entered into force on 26 February 1987, was ratified or accepted by six States and acceded to by two States during 1991. By the end of the year there were 58 Parties.

The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention on Third Party Liability in the Field of Nuclear Energy, which was opened for signature on 21 September 1988, was ratified or accepted by four States during 1991. By the end of the year nine States had expressed consent to be bound. The Protocol will enter into force three months after five States Party to the Vienna Convention and five States Party to the Paris Convention deposit instruments.

The African Regional Co-operative Agreement for Research, Development and Training Related to Nulear Energy (AFRA) (reproduced in document INFCIRC/377), which entered into force on 4 April 1990, was accepted by four States during 1991. By the end of the year 13 States had accepted the Agreement.

Technical co-operation servicing and co-ordination

General

A survey carried out among national liaison officers, project counterparts and Agency staff indicated solid support for the continuation of the two year programming cycle introduced for the Agency's technical co-operation activities in 1989. The Board of Governors subsequently decided, in December 1991, to approve the continuation beyond the initial four year trial period, which would have ended with the 1991-1992 cycle.

Developments to enhance productivity within existing budgetary constraints continued. Through redeployment of staff, an information systems unit was set up to support and develop efficient computer based information and automation systems specific to the needs of the technical co-operation programme.

In 1990, the Agency ranked eighth among the thirty-three organizations of the United Nations system engaged in technical co-operation in terms of the total value of the annual technical co-operation delivered. Excluding the major UN system funding organizations (UNDP, the United Nations Fund for Population Activities (UNFPA) and the United Nations Children's Fund (UNICEF)), the Agency is the second largest provider of technical co-operation from its own resources within the system.

AFRA

Three additional Member States in Africa joined the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) in 1991.

Resources and implementation

Total new resources available for technical co-operation increased in 1991 by 10.2% ($4.5 million) over the previous year, to $49.1 million. As the 1990 figure was artificially low owing to a substantial loss on exchange, it would be more meaningful to compare the 1991 resource figure of $49.1 million with that of 1989, when it reached $50.1 million.

After stabilizing in 1990, the percentage of the target for the Technical Assistance and Co-operation Fund (TACF) which was met through pledges went into further decline, from 85.3% in 1990 to only 78.4% in 1991. This development gives reason for concern as the TACF now accounts for four fifths of the total available resources. As in most years, additional income to the TACF from various sources ($3.1 million) was offset largely by exchange losses ($2.6 million).

As the small UNDP programme consists of only a few large scale projects, delays in any of them have a perceptible impact on the performance of the UNDP funded part of the programme as a whole. This occurred in 1991, when a large scale project in Albania was held up at the request of UNDP owing to circumstances in the country. As a consequence, the UNDP share in the Agency's technical co-operation resources dropped below 5%.

The overall implementation rate of 63.6% in 1991 was well within the range prevailing over the past five years (from 56.5 to 67.8%). In the TACF portion of the programme, this five year range of the annual implementation rate extended from 58 to 71.3% and in extrabudgetary resources from 37.5 to 56.5%. For UNDP, the typical range was from 70 to 89%; as mentioned earlier, the low 1991 figure of 47.1% illustrated the effect of the postponement of one project.

Implementation by resource category

Resource category	Adjusted programme ($)	Share of total programme (%)	Net new obligations ($)	Implementation rate (%)
TACF	51 934 343	76.7	35 093 180	67.6
UNDP	3 210 360	4.7	1 513 194	47.1
Extrabudgetary	11 262 970	16.6	5 874 898	52.2
Funds-in-trust	1 366 999	2.0	614 889	45.0
Total	67 774 672	100.0	43 096 161	63.6

Programme delivery and support

A total of 1301 projects were operational during 1991, ranging in size from one month of expert services valued at $8850 to multi-year projects with a 1991 budget of around $1.3 million. A total of 229 projects and 41 training courses were completed during the year.

During 1991, 1160 months of expertise were provided through 2306 expert/lecturer assignments. Five hundred experts' reports were submitted to governments. A total of 4112 months of training was provided to 2351 persons through fellowships, training courses and scientific visits. The provision of equipment involved the processing of 3772 purchase orders.

Technical co-operation programme delivery

	1987	1988	1989	1990	1991
Number of expert/lecturer assignments	1808	2023	2144	2221	2306
Number of expert/lecturer months served	1356	1239	1246	1217	1160
Number of expert/lecturer assignments undertaken by Agency staff	407	430	444	512	552
Number of purchase orders processed	3701	3386	3894	3763	3772
Number of fellows in the field	870	682	732	814	747
Number of visiting scientists	160	156	192	243	203
Number of participants in training courses	945	1109	1265	1358	1401

The delivery of the technical co-operation programme could not take place without the active involvement of other departments of the Agency. The technical divisions of the Secretariat play a major role in supporting technical co-operation activities. During 1991, a total of 174 technical officers not only supported the 1301 operational projects, but also undertook over a thousand fellowship evaluations and carried out 552 assignments in the field.

Technical co-operation activities carried out by area of activity

Area of activity	Number of technical officers	Number of projects supported	Number of fellowship applications evaluated	Number of expert/lecturer assignments	Number of months/ days
Food and agriculture	24	252	219	83	22/4
Human health	13	167	135	65	20/9
Physical and chemical sciences	23	364	262	79	23/24
Agency's Laboratory	16	102	60	59	38/8
Subtotal	76	885	676	286	104/15
Nuclear safety	47	226	206	130	32/17
Nuclear power	13	59	84	39	10/10
Nuclear fuel cycle and waste management	18	88	79	43	8/25
Scientific and technical information	4	13	9	8	2/5
Subtotal	82	386	378	220	53/27
Other	16	30	19	46	9/12
Total	174	1301	1073	552	167/24

Assistance provided to various regions

Region	Overall share (%)						
	1986	1987	1988	1989	1990	Average, 1986–1990	1991
Africa	19.9	18.4	20.1	20.5	18.2	19.4	21.1
Asia and Pacific	26.7	30.0	29.0	29.6	31.9	29.4	29.8
Europe	13.6	18.9	13.8	13.4	16.3	15.2	14.4
Latin America	22.4	20.3	23.0	25.8	22.1	22.7	22.8
Middle East	3.1	2.1	3.0	2.1	2.4	2.5	2.8
Interregional	14.3	10.3	11.1	8.6	9.1	10.7	9.1

Note: Assistance provided on the basis of disbursement from all sources of funds.

Distribution of assistance

The relative shares of the various regions in the assistance provided during the year under review closely followed the average during the period 1986-1990, with an increase in Africa's share being discernible. With respect to the Agency's regular programme of technical co-operation for 1991, based on approvals by the Board, Africa's share of the adjusted programme was the largest at 26.1%.

In terms of the Agency's budgetary areas of activity, 20.4% of all technical co-operation disbursements were made in the field of food and agriculture, followed by 18.6% for physical and chemical sciences and 16.8% for industry and earth sciences. Radiation protection, safety and radioactive waste

Distribution of assistance (cont.)

management together accounted for 19.7% of all disbursements. The distribution of technical co-operation disbursements for each area of activity differed from region to region. In Africa, for instance, there was a pronounced emphasis on activities related to food and agriculture, while in Europe physical and chemical sciences dominated.

Distribution of technical co-operation disbursements by area of activity and region

Area of activity	Inter-regional	Africa	Latin America	Asia and Pacific	Europe	Middle East	*Total*
Nuclear power	451.6	251.9	116.2	715.6	870.2	0.0	2 405.5
Nuclear fuel cycle	63.5	251.8	30.6	687.8	242.8	50.2	1 326.7
Radioactive waste management	213.4	231.0	144.2	423.3	253.9	0.0	1 265.8
Comparative assessment[a]	0.0	0.0	0.0	0.0	19.5	0.0	19.5
Food and agriculture	436.7	3108.4	2 454.0	2 604.1	684.3	126.1	9 413.6
Human health	207.6	1688.7	1 056.7	2 574.4	530.8	58.4	6 116.6
Industry and earth sciences	17.0	1096.9	2 673.1	2 509.8	873.6	593.1	7 763.5
Physical and chemical sciences	609.4	1671.3	2 023.6	2 536.2	1570.4	147.3	8 558.2
Radiation protection	833.6	1088.3	1 334.5	1 059.1	734.3	283.4	5 333.2
Safety of nuclear installations	619.1	182.9	420.8	411.4	837.3	4.7	2 476.2
Safeguards	0.0	0.0	0.0	0.3	0.0	0.0	0.3
Direction and support	746.9	137.3	238.1	198.6	28.7	47.0	1 396.6
Total	4198.8	9708.5	10 491.8	13 720.6	6645.8	1310.2	46 075.7

Note: All figures are in thousands of dollars.

[a] The full title of this area of activity is: 'Comparative assessment of nuclear power and other energy sources'.

Evaluation

Evaluation continues to play an important role in enhancing the effectiveness of the Agency's technical co-operation activities. Recommendations made in earlier evaluations have been instrumental in introducing several improvements in programme and project management. In December 1991, two new sectoral evaluations — on assistance in research reactor related activities and on technical co-operation activities in nuclear physics in Africa — were completed, and an in depth review of RAPAT and WAMAP was initiated. Two detailed country evaluations were carried out in 1991, as well as 17 Headquarters based country reviews. The Interim Project Implementation Report (IPIR), in addition to providing a valuable mechanism for monitoring, now also contains non-financial assessments of project execution. Over the first nine months of 1991, the IPIRs received indicated that the implementation of 42% of the projects was rated as 'excellent', that of 53% was rated as 'good' or 'reasonable' and that of only 5% had to be rated as 'poor'.

Specialized service activities

Publlic information

Public information work centred on the need to accommodate the surge in media and public attention on the Agency's Iraq related activities in the wake of the Persian Gulf crisis and United Nations Security Council Resolution 687. An increased number of television networks in Europe and North America produced documentaries on the Agency's work in 1991.

Other issues which attracted major coverage in the media were the International Chernobyl Project (on which a number of information brochures were issued) and the Agency's safety related work on nuclear power plants in central and eastern Europe.

Video production was expanded to help meet external and internal needs arising in key areas, as well as to provide new items for the media seminar programme.

Media seminars

Three information seminars were held — in Hungary, Japan and Thailand. A report entitled 'Nuclear Power: Communicating for Confidence' was published, reflecting the outcome of the previous year's Public Information Forum in Vienna, and a second Forum for specialists from over 30 Member States was held in September.

Periodicals and brochures

The layout and presentation of the Agency's issue oriented quarterly publication *IAEA Bulletin* were redesigned. In addition to other regular periodicals and illustrated brochures on special topics (such as CRPs), the third edition of 'Highlights' — the popularized version of the Annual Report — was produced. The Fact Sheets series was expanded for use at media seminars and for wider distribution, covering topics such as nuclear applications in medicine, and energy, electricity and nuclear power.

Symposia and exhibitions

Media related support was provided at the Helsinki Senior Expert Symposium on Electricity and the Environment and for an exhibition at the United Nations Headquarters in New York.

INIS

The Arab Atomic Energy Agency and Albania joined the International Nuclear Information System (INIS) in 1991. This brought the number of participating Member States to 80 and international organizations to 16.

In 1991, a total of 92 012 records were added to *INIS Atomindex*, bringing the database to 1 539 972 records. All *INIS Atomindex* products are now available on microfiche in addition to the printed form, and the INIS database is available on-line in Member States. In 1991, INIS Liaison Officers began receiving free subscriptions to *INIS Atomindex* on CD-ROM. These subscriptions will contain archival and current disks and include free updates. The INIS CD-ROM is available to the general public through a commercial distributor.

The INIS Clearinghouse distributed about 460 000 microfiches, representing over 23 million printed pages of non-conventional literature. By the end of the year, the collection of documents approached 255 000 (around 330 000 microfiches).

Following suggestions made by Member States and the recommendation of the 7th Advisory Committee for INIS, the INIS subject scope was expanded to include the economic and environmental effects of non-nuclear energy sources, while astrophysics and cosmology were excluded. The subject classification scheme was revised to conform to the international scheme for physics.

A software package FIBRE (Friendly Inputting of Bibliographic Records) was completed and distributed to INIS members. Using FIBRE, members can more easily carry out their INIS inputting responsibilities and provide the input in a more efficient machine readable form.

The 8th Advisory Committee for INIS met in December with the main agenda item being future developments for INIS. The Committee reaffirmed the current role of the INIS Secretariat as a database producer, with distribution being the responsibility of the Member States. It strongly recommended an INIS user study to determine the services and products which INIS should develop. It also recommended that the INIS Secretariat facilitate the worldwide exchange of information in the full energy scope, an exchange currently limited to IEA members in the Energy Technology Data Exchange (ETDE).

Information about INIS

	1987	1988	1989	1990	1991
Membership	89	93	94	94	96
Member States	75	78	79	79	80
Organizations	14	15	15	15	16
No. of records in *INIS ATOMINDEX*	1 159 156	1 266 075	1 352 356	1 447 960	1 539 972
Records entered into *INIS ATOMINDEX*	101 118	106 919	86 281	95 504	92 012
Non-conventional literature in *INIS Atomindex*	26 807	29 479	24 652	26 032	28 723
Number of INIS members using direct access	33	28	27	32	32
On-line access hours by external users	1 131	758	773	700	415
Number of INIS members receiving output tapes	42	43	43	35	32
Microfiche dispatched:	500 000	600 00	570 000	530 000	491 000
non-conventional literature and COM[a]	37	37	37	36	34
Number of paid subscriptions to *INIS ATOMINDEX*	828	740	635	608	519
Number of free subscriptions to *INIS ATOMINDEX*	288	267	250	252	241

[a] Computer output on microfiche.

Publications

Series and No.	Title
INIS-11 (Rev. 18)	INIS: authority list for journal titles
INIS-6 (Rev. 22)	INIS: authority list for corporate entries and report number prefixes
INIS-13 (Rev. 30)	INIS: thesaurus
INIS-5 (Rev. 7)	INIS: terminology and codes for countries and international organizations
INIS-3 (Rev. 7)	INIS: subject categories and scope descriptions
Newsletter	INIS newsletter, No. 47

Shared support services

Library collection and services

After the publication of the VIC Library Film and Video Catalogue 1991 in September, film loan requests from Member States increased significantly. The catalogue contains descriptions of 393 films owned by the Library. Archival films and genetic engineering films attracted special interest. The VIC Library's Current Awareness Bulletin service was updated from a 14 to 16 subject series to better meet programme needs. With an average of 580 recipients, the service distributed 17 103 issues during the year.

To make the information more accessible to users, the Institutions Collection (a collection of annual reports, directories and basic information on national and international institutions) was added to the Library's on-line catalogue.

The VIC Library began, in co-operation with the publishing services, to provide cataloguing-in-publication (CIP) data for inclusion in priced Agency publications. CIP cataloguing provides descriptive information (including author, title and subject headings) prepared according to international cataloguing rules. It is of particular value for Member State libraries.

An exhibit was arranged on 'Nobel Prize Winners and the IAEA'. This has been loaned to the ICTP for further display.

Technology in the VIC Library

The major automation effort in 1991 was the identification of suitable replacement software and hardware for the Library's automated applications. Automation of serials management continued.

Upgrading of the Agency's data processing capabilities

In February 1991, the Board of Governors approved allocation of $5 500 000 from the 1988 cash surplus to upgrade the Agency's computer services and provide the necessary computing capability for 1991–1996. A detailed technical acquisition plan was developed in April 1991. Implementation of the project comprised two major phases: upgrading of the central computing facility; and strengthening of the decentralized technical infrastructure.

In July the Agency invited prospective vendors to bid for upgrading of the central computing facilities. After evaluation of the bids, contracts were signed with the vendors for $4 000 000. The new equipment was received by the Agency in September and consisted of the following hardware items:

- Hitachi 7890 disk subsystem for Safeguards
- IBM ES/9000 processor model 210 for Safeguards
- IBM ES/9000 processor model 320 shared by all other users
- IBM 3745/170 telecommunication controllers
- DEC VAX configuration (models 4000 and 5100).

All equipment was installed without interruption to users and has been operating satisfactorily. Production migration to the latest level of the operating system is being completed. Users are now experiencing a significant improvement in performance and response times.

Equipment to strengthen the Agency's decentralized technical computer infrastructure was estimated to cost $1.5 million. Preparatory work was carried out in 1991 for the effective utilization of this fund, including the undertaking of a study, with the help of international consultancy companies, to define a Standard Technology Architecture (STA), to design topological and connectivity plans, and to develop implementation plans for the new architecture. However,

Upgrading of the Agency's data processing capabilities (cont.)

acquisition of the hardware and software products was deferred until 1992 in view of the financial situation which prevailed during the last quarter of 1991.

Internal network

The local area network (LAN) capability was expanded to a total of 500 users in 1991 and integrated into the fibre optics backbone network in the Agency buildings. Over 200 new end user devices (mostly personal computers) were installed and LAN cabling of an additional six floors was completed, thereby providing cabling to most Agency offices.

External network

Several enhancements were made to the external network: the external dial-in facilities for Member States were upgraded; the computer mainframe telecommunications front end processor was replaced with new technology; electronic mail facilities to the United Nations, in New York, were extended; a pilot project allowing Permanent Missions in Vienna to access the Agency's computer for electronic mail purposes was completed; and a data communications facility was installed between the Agency and UNOV. Extensive use of the international mail system EARN/BITNET was made for the exchange of messages between the Agency and affiliated institutions in Member States.

Decentralization

An STA was approved in October that would provide the infrastructure for the decentralization of computing in a planned and supported manner throughout the Agency. A new charging policy was approved for implementation in 1992, creating a budget for central computer services and funds in the divisional budgets to be obligated only when divisions actually use the central services. New applications development emphasized LAN based software systems for improving office productivity in a decentralized environment. The central computer services were streamlined to better support decentralized computing, including the transfer of some programming staff to the substantive divisions.

Applications

Significant applications development was carried out by central services for the International Nuclear Event Scale (INES) system, the Emergency Response System, a database on waste management, and improvements to PRIS, INIS and technical co-operation management and implementation support.

Publishing

In 1991, the cumulative total number of copies of books sold during the history of Agency publishing rose above the 2 million mark. The total number of copies of priced publications distributed free to Member States stood at about 2.25 million at the end of the year.

During 1991, over two hundred titles were issued. In addition to those listed or mentioned in other parts of the Annual Report, 12 books were published in Chinese, 4 in French, 9 in Russian and 11 in Spanish. Of particular note, as being outside the range of serial publications, were the Overview and Technical Report on the results of the International Chernobyl Project and the Key Issues Papers from the Senior Expert Symposium in Helsinki.

A new series of subject oriented publications catalogues was started, these being cheaper to produce and more useful to prospective customers.

The cover of the principal form of technical documents — IAEA-TECDOCs — was redesigned to bring the series into line with modern publishing standards.

Computerization of all book production data was completed, this being a necessity in view of the fact that it is common to have over one hundred books in various states of preparation at any given time.

Printing

The Common Printing Service continued to provide document and publications printing services for the Agency and also for UNIDO and the United Nations bodies based at the VIC. In 1991, the income from work for other organizations was around $1.84 million. The output of the Common Printing Service was 188 million page impressions, compared with 185 million in 1990.

Publications

Series and No.	Title
Annual publication	Vienna International Centre Library film and video catalogue 1991

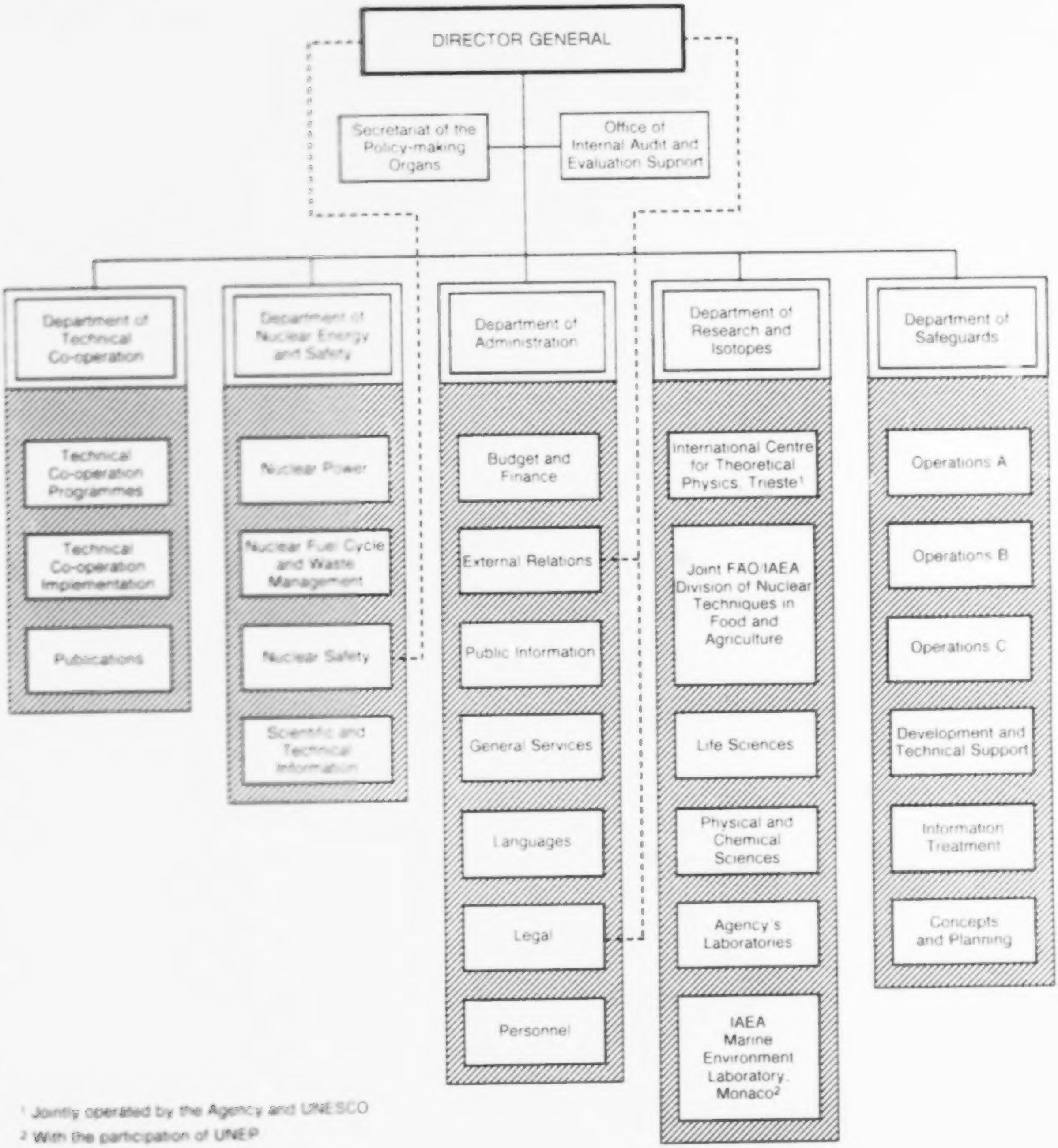
List of abbreviations

ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
CANDU	Canadian deuterium–uranium (reactor)
CEC	Commission of the European Communities
CERN	European Organization for Nuclear Research
CMEA	Council for Mutual Economic Assistance
CRP	Co-ordinated research programme
EEC	European Economic Community
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
HTGR	High temperature gas cooled reactor
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
ICTP	International Centre for Theoretical Physics
IEA	International Energy Agency (OECD)
IGCP	International Geological Correlation Programme
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Office
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INTOR	International Tokamak Reactor
ISO	International Organization for Standardization
LMFBR	Liquid metal cooled fast breeder reactor
LWR	Light water reactor
NDA	Non-destructive assay
NEA	Nuclear Energy Agency of the OECD
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NUSS (programme)	The Agency's programme on nuclear safety standards for nuclear power plants
NWAL	Network of Analytical Laboratories
OAU	Organisation for African Unity
OECD	Organisation for Economic Co-operation and Development
OPANAL	Organismo Proscripción Armas Nucleares América Latina Caribe
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (INFCIRC/167)
SAL	Safeguards Analytical Laboratory
SQ	Significant quantity
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
VIC	Vienna International Centre
WANO	World Association of Nuclear Operators
WASP	Wien Automatic System Planning Package

WHO	World Health Organization
WMO	World Meteorological Organization
WOCA	World outside centrally planned economies area
WWER	Water cooled and moderated reactor (Soviet Union)

ORGANIZATIONAL CHART

(as of 31 December 1991)


DIRECTOR GENERAL
Secretariat of the Policy-making Organs
Office of Internal Audit and Evaluation Support
Department of Technical Co-operation
Technical Co-operation Programmes
Technical Co-operation Implementation
Publications
Department of Nuclear Energy and Safety
Nuclear Power
Nuclear Fuel Cycle and Waste Management
Nuclear Safety
Scientific and Technical Information
Department of Administration
Budget and Finance
External Relations
Public Information
General Services
Languages
Legal
Personnel
Department of Research and Isotopes
International Centre for Theoretical Physics, Trieste[1]
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Life Sciences
Physical and Chemical Sciences
Agency's Laboratories
IAEA Marine Environment Laboratory, Monaco[2]
Department of Safeguards
Operations A
Operations B
Operations C
Development and Technical Support
Information Treatment
Concepts and Planning

[1] Jointly operated by the Agency and UNESCO

[2] With the participation of UNEP